THE OHIO JOURNAL OF SCIENCE

VOL. XL MARCH, 1940 No. 2

CRINOIDS FROM THE SILICA SHALE, DEVONIAN, OF OHIO

GRACE A. STEWART,
Department of Geology,
Ohio State University

Recently the writer has had the privilege of examining some crinoids from the private collection of V. E. Ladd of Toledo, Ohio. The specimens were all collected from the Silica shale in the Kelley's Island Lime and Cement Company quarry at Silica, Lucas County, Ohio. They represent two new species, and a young specimen of *Arthracantha carpenteri* (Hinde) which has the arms exceptionally well preserved.

One of the new species, *Gilbertsocrinus ohioensis* n. sp., belongs in a genus heretofore unrecognized in the Devonian strata of Ohio. Thus far eight species of this interesting genus have been collected in rocks of Hamilton age. The species and their occurrences are as follows: *G. greenei* Miller and Gurley and *G. indianensis* Miller and Gurley from Clark County, Indiana; *G. spinigerus* (Hall) from the Moscow (Ludlowville) of western New York; *G. alpenensis* Ehlers from the Hamilton near Alpena, Michigan, and the Ludlowville of western New York; *G. intersculptus* Goldring from the Skaneateles formation, Unadilla valley, New York; *G. rarispinus* Goldring from the Moscow formation, Georgetown, New York; *G. spinonodosus* Goldring, Tichenor formation (Ludlowville), Eighteen Mile Creek, New York; and *G. multicalcaratus* Goldring from the Kashong beds of the Moscow formation, East Bethany, New York. Goldring has shown that *G. indianensis* is synonymous with *G. spinigerus*.

This very interesting series of species, although closely related, show distinct and progressive changes in ornamentation and in the development and distribution of spines. The Ohio species is characterized particularly by the development of strong nodes on only the radial plates.

The second new form, *Euryocrinus? laddii* n. sp., has been placed only tentatively in the genus *Euryocrinus*. It doubtless represents an undescribed genus of the Ichthyocrinidae but the incompleteness of the specimen, particularly in the interradial areas, makes it unwise to erect a new genus until additional and better material can be found.

Dr. Winifred Goldring, of the New York State Museum, was kind enough to examine the crinoid specimens discussed in this paper. The writer wishes to acknowledge her helpful suggestions with deep appreciation.

Order **Camerata** Wachsmuth and Springer

Family **Rhodocrinidae** Roemer

Gilbertsocrinus ohioensis n. sp.

(Plate I, figs. 1–4)

Description.—This species is represented by two imperfectly preserved specimens, the combined characters of which are sufficient to demonstrate its distinctiveness from any previously described species of the genus.

The measurements of the two dorsal cups which have somewhat different proportions are: height to arm bases 10 mm., greatest width about 14 mm. at the arm bases; height to arm bases 8 mm., greatest width 8 mm. at the first primibrachs. Cup somewhat cylindrical in outline and pentagonal in cross section; the smaller specimen is noticeably restricted between first primibrachs and arm bases.

Basal pit wide, of moderate depth, enclosed by basals and lower half of the radials. Although infrabasals are present their general shape and character cannot be determined definitely. Basal plates large, hexagonal in outline, extending wedge-like between the lower half of the radials and forming the re-entrant angles. Radials are the largest plates in the cup, heptagonal in outline, the surface extended into large conspicuous spines. First primibrachs about as high as the radials, hexagonal in outline; primaxils only slightly lower than the first primibrachs, heptagonal in outline.

Primary interbrachials somewhat larger than first primibrachs, hexagonal in outline, extending for half their length between the radials, and resting on the truncated basals below. In four of the interradial areas the primary interbrachial is apparently followed by four rows of interbrachials composed of the series 3, 3, 2, 2. The succession of plates in the posterior interradial area has not been determined.

Secundibrachs 2 x 10. The second is axillary; on its inner side an arm arises, and on its outer an interradial appendage. Intersecundibrachs not determined. Each arm bifurcates on the fourth or fifth secundibrach, the inner arm again on the third tertibrach, giving three arms to the half ray or six to the ray. These have been determined from two rays only, the others are not sufficiently well preserved to be accurately counted.

Arms ten, short, zigzag biserial, with long pinnules.

The character of the tegmen cannot be definitely determined. However it appears to be low as is characteristic of most other species of the genus, and is composed of numerous small nodose plates. Interradial tubular appendages are formed from single series of cylindrical discs; evidently not recurved.

Column round, 2 to 2.5 mm. in diameter; axial canal large.

The ornamentation is the type distinctive of other species of the genus. Long blunt spines are present on all the radials. A radial ridge extends from the base, forking on the primaxil. On the first primibrach it is modified into a low, rounded node. All of the interradial plates, with the exception of the primary interbrachial, have distinct nodes at the center. These are connected by low ridges which define rhombic outlines on the surface of the plates. Nodes are also present on the tegmen plates but their character and distribution cannot be definitely determined.

Remarks.—The two specimens upon which this species is based consist of two dorsal cups, one of which has a portion of the arms preserved. One is larger and more robust than the other, but details of surface sculpture and other features seem to be identical and thus justify inclusion in the same species. The form is of much interest because it adds yet another variant to the interesting assemblage of species of *Gilbertsocrinus* of middle Devonian age.

The lack of strong nodes on all but the radials seems to be the outstanding feature of the species. In this respect it resembles *G. rarispinus* Goldring, but differs in having strongly developed radial ridges, and less prominent ridges connecting the nodes in the interradial series. From *G. spinigerus* (Hall) it differs in the absence of spines on the primary interbrachial, and in having biserial rather than uniserial arms. It may be separated from *G. greenei* by the absence of spines on both primary interbrachials and first primibrach. From *G. alpenensis* Ehlers it differs in the absence of spines on the first primibrach. The arm arrangement is very much like *G. intersculptus* Goldring but there are no spines on the primibrachs.

Horizon and Locality.—Silica shale, middle Devonian, probably lower ten feet, quarry Sandusky Lime and Cement Company, Silica, Lucas Co., Ohio.

Family **Hexacrinidae** Wachsmuth and Springer

Arthracantha carpenteri (Hinde)

(Plate I, fig. 5)

A very fine specimen of a young *Arthracantha carpenteri* (Hinde) in Mr. Ladd's collection deserves special mention because to my knowledge only one other specimen has been figured which even approaches it in the completeness and excellence of the arm preservation. The other specimen from the Hamilton shale at Thedford, Ontario, Canada, was originally described and figured by Elvira Wood (7), and later refigured by Winifred Goldring (2). Miss Wood's specimen is evidently a mature

form and is considerably larger than the Silica shale specimen. The arms have been distorted somewhat, and the upper part is missing, so that the true outline of the crown is not evident.

The Silica shale specimen, on the other hand, has the arms complete to the tips, thus showing the manner of infolding at the distal end. Although it is crushed on one side, the original outline of the crown is intact, and apparently has not been impaired in any way.

The larger Ontario specimen has longer arms with more frequent bifurcations. At least three bifurcations occur above the primaxil and probably a fourth, since the upper portion of the crown is incomplete.

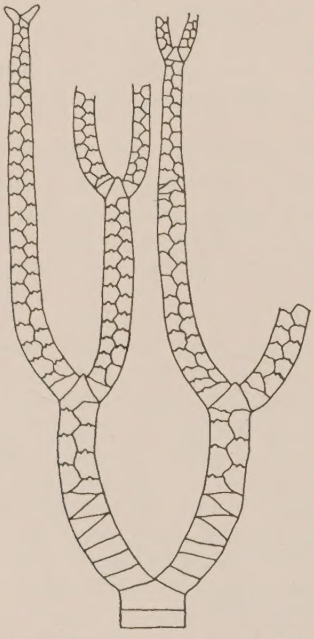


Fig. 1. Analysis of plate arrangement in left anterior arm of *Arthracantha carpenteri* (Hinde).

The Silica shale form, on the other hand, has just two bifurcations above the primaxil on all but one arm, where a third division can be seen very close to the tip.

A noteworthy feature of the Ohio specimen is the strong development of the distally pointing tubercles on the axillaries, which seem to be proportionately stronger than in Wood's specimen. They are extended into short spines, one on the secundaxil, and two on the tertaxil. Here and there, with no definite arrangement, a large, strong tubercle is developed between bifurcations. In all other respects the detail of the arms seems to be identical with the Canadian specimen as also are the details of the dorsal cup.

Fig. 1. *Horizon and Locality.*—Silica shale, Kelley's Island Lime and Cement Company quarry, Silica, Ohio.

Order **Flexibilia** Zittel

Suborder **Sagenocrinoidea** Springer

Family **Ichthyocrinidae Angelin** (em. W. and Sp.)

Euryocrinus ? laddii n. sp.

(Plate I, fig. 6)

Description.—A medium sized species, with an elongate, more or less ovoid body, the arms infolding distally. A fairly complete laterally compressed crown measures 37 mm. in height, and 7 mm. in width at the base of the cup, increasing in width to 25 mm. at the tertaxils the region of greatest width.

Base of dorsal cup broadly and shallowly concave, pentagonal in outline. The condition of preservation is such that neither infrabasals nor basals can be clearly defined. Apparently three large infrabasals are present entirely surrounded by the basals. Although the actual outline of the basals cannot be accurately determined they are seen to extend in side view in two interradial areas as narrow triangular facets between the radials; the posterior basal appears to be longer than the others and rectangular in outline. Radials wider than high, hexagonal in outline, approximately 4 mm. in breadth at the widest portion just above the middle, and 2.5 mm. in height. Upper margin of radials somewhat arcuate, the lower curving into the edge of the basal facet. Surface smooth except for pronounced vertical and transverse angularities. The vertical angularities form the points of the basal pentagon, the basals making the re-entrant angles.

Primibrachs three, wider than high, the middle one somewhat lower than the other two; first primibrach hexagonal in outline, second somewhat quadrangular, while the primaxil is pentagonal. All three are practically the same width. The dimensions of the primaxil are: height 2.75 mm., width 6 mm.

Anal plate angular, the exact outline not determined with certainty; followed by several series of angular plates whose number cannot be determined. In the other interradial areas at least one row of angular plates is present, extending up to the secundibrachs. In two areas the primary interbrachial has been preserved and is seen to be pentagonal in outline. Unfortunately most of the plates in the interradial series have been destroyed in the cleaning so that their character is not certainly known.

Arms dichotomous, bifurcating on the third secundibrach; secundibrachs somewhat narrower than primibrachs and higher in relation to the width. One large intersecundibrach may have been formerly present but has not been determined definitely. First secundibrach pentagonal, second somewhat quadrangular, while the secundaxil is pentagonal and slightly higher than the others. The second bifurcation takes place in the seventh tertibrach on the outer branch, and in the fourth on the inner branch; from the first tertibrach the arms abut, just how high cannot be determined with accuracy. Plates are short and wide and

interlock laterally by angular margins with prominent ridges. Succeeding brachials narrow and high. The third bifurcation takes place on the twelfth quartibrach in the outer branch, and on the seventh quartibrach in the inner. The intervals of bifurcation above this cannot be determined.

Column not preserved, but judging from the size of the basal facet it was evidently large.

The only ornamentation consists of the angularities on the radial and lower brachials and the angular ridges at the margins of the interlocking plates.

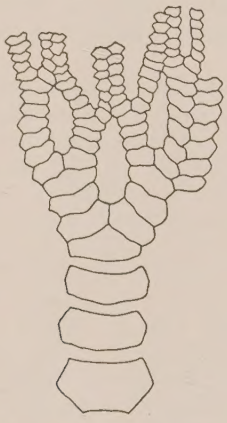


Fig. 2. Analysis of right posterior ray of *Euryocrinus ladii* n. sp.

Remarks.—This interesting form is represented by one incomplete crown. Its characters are sufficiently striking to justify separation from all described species. It is placed provisionally in *Euryocrinus* with which genus it seems to agree more closely than any other genus of the Ichthyocrinidae. It differs, however, in the higher incorporation of the brachial plates in the dorsal cup which includes to at least the secundibrachs and probably beyond; and the anal series of plates are much more numerous. Other genera of the Ichthyocrinidae of Devonian age which have resemblances in common with the form under consideration are *Clidochirus*, *Synaptocrinus*, and *Dactylocrinus*. However, all three of them have only two primibrachs, while this form has three. From *Clidochirus* it can further be separated in the presence of interradial plates in all of the interradial areas instead of just the posterior, and in the absence of a radianal plate. *Synaptocrinus* lacks plates in all the interradial areas, and *Dactylocrinus* has a different arm arrangement above the secundibrachs.

Evidently only one other species of the genus *Euryocrinus* has been recognized in Devonian rocks in North America, *E. barrisi* Springer. This species is represented by two calices from the Traverse group of the middle Devonian at Partridge Point near Alpena, Michigan, and a more complete specimen from rocks of Hamilton age at New Buffalo,

Iowa. *Euryocrinus ? laddii* n. sp. may be separated from it not only by the generic differences just discussed but also by the different shape of the crown, the absence of nodose projections at the margin of the brachials, and the less sharply angular rays.

Additional and better preserved material will no doubt necessitate the separation of this form under a new genus.

The species is named in honor of V. E. Ladd, of Toledo, Ohio, who kindly loaned the specimen to the writer for study.

Fig. 2. *Horizon and Locality.*—Silica shale, probably lower ten feet, Kelley's Island Lime and Cement Company quarry, Silica, Ohio.

REFERENCES

(1) **Ehlers, G. M.** Two new crinoids from the Devonian of Michigan. Contrib. Mus. Geol., Univ. Mich., Vol. 2, No. 66, pp. 99–101, pl. 1, figs. 1, 2. 1925.

(2) **Goldring, Winifred.** The Devonian crinoids of the State of New York. New York State Mus., Mem. 16. 1923.

(a) Some Hamilton crinoids of New York and Canada. Buf. Soc. Nat. Sci., Vol. 15, No. 3, pp. 182–200, pls. 1, 2. 1934.

(b) New and previously known middle Devonian crinoids of New York. Ann. Carnegie Mus., Vol. 24, pp. 349–369, pls. 25–27. 1935.

(c) Some Hamilton (Devonian) crinoids from New York. Jour. Paleo., Vol. 10, No. 1, pp. 14–22, pls. 6, 7. January, 1936.

(3) **Hinde, G. J.** Description of a new species of crinoid with articulating spines. Ann. Mag. Nat. Hist., Ser. 5, Vol. 15, pp. 157–175. 1885.

(4) **Springer, F.** Crinoidea Flexibilia. Smith. Inst. Publ. No. 2501. 1920.

(5) **Stauffer, Clinton R.** Descriptions of some new species of Devonian fossils. Jour. Geol., Vol. 26, No. 6, pp. 555–560, pls. 1–3. 1918.

(6) **Thomas, A. O.** Echinoderms of the Iowa Devonian. Iowa Geol. Surv., Vol. 29, pp. 385–550, pls. 35–54. 1920.

(7) **Wood, Elvira.** On new and old middle Devonian crinoids. Smith Misc. Coll., Vol. 47, No. 1471, pp. 56–84, pls. 15, 16. 1904.

EXPLANATION OF PLATE I

(All figures magnified ×2)

Gilbertsocrinus ohioensis n. sp.

Fig. 1. Lateral view of specimen showing strong development of radial spines and proximal portion of arms.

Fig. 2. Basal view of same specimen.

Fig. 3. Lateral view of larger specimen showing the forking of the radial ridge on the primaxil, and the arm bases.

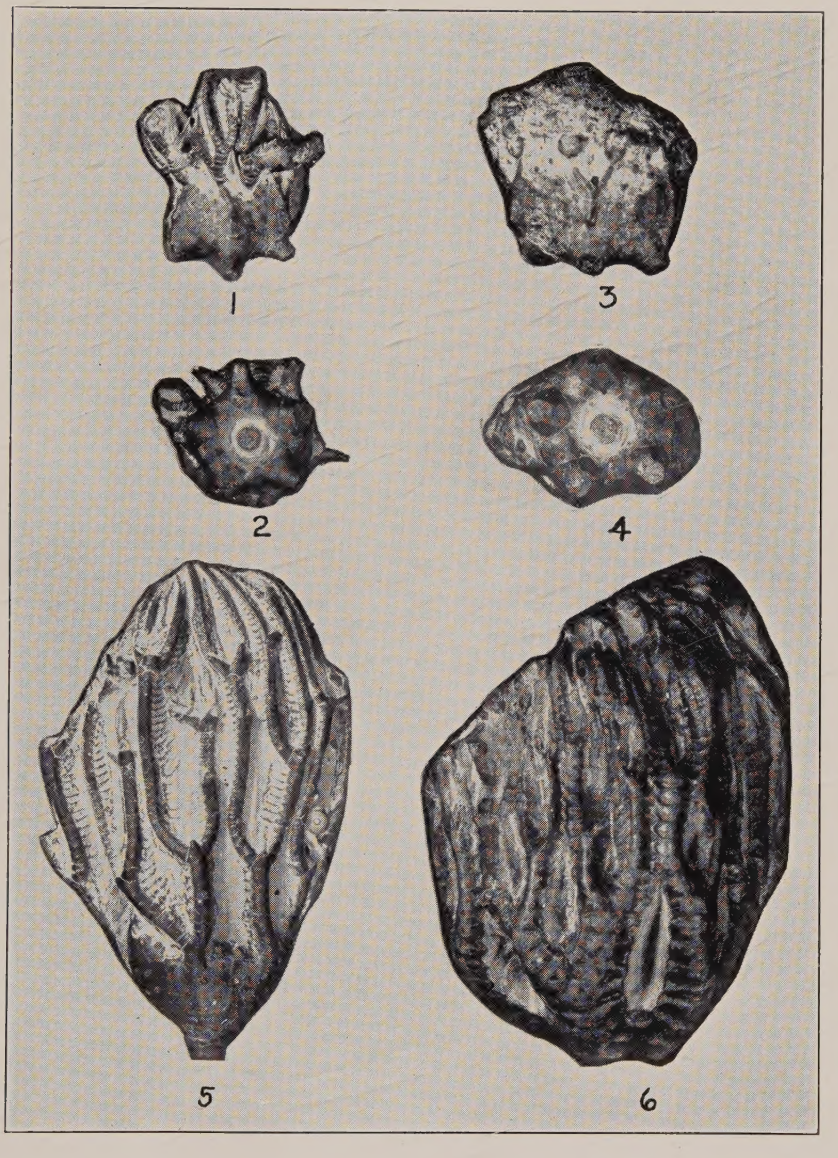
Fig. 4. Basal view of same specimen.

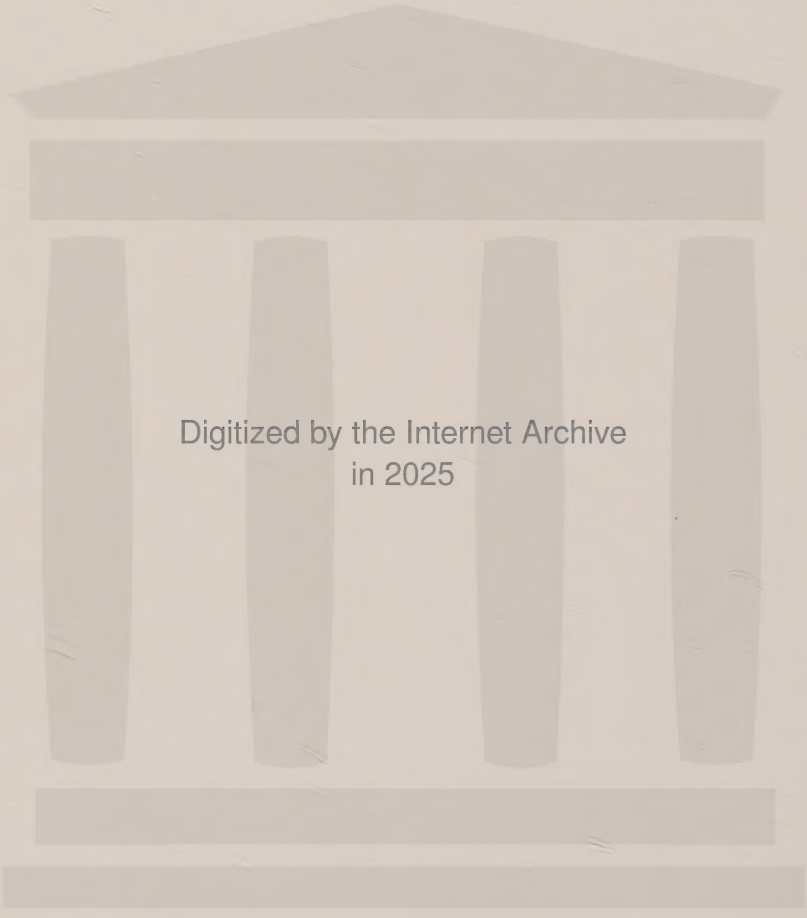
Arthracantha carpenteri (Hinde)

Fig. 5. Right posterior view of specimen showing especially well the manner of arm bifurcation and the strong development of blunt spines on the arms.

Euryocrinus ? laddii n. sp.

Fig. 6. Right posterior view of crown showing character of dorsal cup and abutting arms. In the lower right interradial area one plate of the interradial series is visible.


1
3
2
4
5
6



Digitized by the Internet Archive
in 2025

https://archive.org/details/ohio-journal-of-science_1940-03_40_2

THE MECHANISM OF DRUG CONTROL OF GASTRIC MOTILITY[1]

FRANK E. HAMILTON, M.D. and GEORGE M. CURTIS, M.D.,
From the Department of Research Surgery
of the Ohio State University

Recent clinical investigation has demonstrated the significance of the motor behavior of the human stomach during certain pathologic states. Hoffmeister, Cannon, and Magnus (30) were among the first investigators to recognize this physiologic principle. Their studies of gastric motility led to investigations of the emptying time of the stomach and the effect of denervation operations on the activity of the stomach. Most of the early studies were conducted on animals and the results obtained lacked uniformity. More recently, members of the Department of Research Surgery of the Ohio State University have had the opportunity to study gastric motility in the human subject.

Barron and Curtis (1) found that following bilateral splanchnic resection there ensues increased motility of the human stomach, while after subdiaphragmatic resection of the left vagus (2) there follows a decreased motility. Veach (36) and Veach, Lauer, and James (37) found that movements of the normal as well as the pathologic human stomach could be controlled by various drugs. Morphine was predominantly motor to the human stomach, while atropine was constantly inhibitory. Prostigmin administered alone was inhibitory to the human stomach, but when administered in conjunction with atropine it became motor.

Recently these investigations in clinical physiology have been put to clinical tests in the management of postoperative gas pains and nausea, the control of the pain of biliary colic, and the relief of certain of the symptoms of obstructive duodenal ulcer. Nevertheless, valuable as is the application of these findings from a clinical standpoint, the factor of fundamental importance is the nature of the mechanism of control of gastric motility.

Under the older theories, visceral motility was thought to be the result of a balance between the activities of the

[1]Presented before the Ohio Academy of Science; Section of Medical Science; Cincinnati, April 14, 1939.

sympathetic and parasympathetic divisions of the autonomic nervous system. Accordingly, the motor response of the stomach, following administration of any certain drug, would be the result of stimulating or inhibiting one or the other of the two autonomic divisions, and thus upsetting the balance between these two forces.

However, McCrea (29), McSwiney and Wadge (31), Barry (3), and Harrison and McSwiney (24) have by the use of experiment shown the presence of motor and inhibitory fibres in both the vagus and splanchnic nerves. Gayet, Minz, and Quivy (23) have recently supplied further confirmation of these observations by demonstrating the release of acetylcholine following stimulation of the splanchnic nerve. These investigators have demonstrated that the effect of stimulation of the cut end of either the vagus or the splanchnic may result in either increased activity or inhibition of the stomach; moreover, the result appears to depend largely on the existing degree of gastric *tonus* present at the time of stimulation.

However, it appears to be clear that the vagi are predominantly motor to the stomach while the splanchnics are predominantly inhibitory.

Further evidence of the inadequacy of the older theory postulating the dependence of visceral motor function on a balance between the sympathetic and parasympathetic divisions, is furnished by the recent work of Dale (15, 16, 17, 18, 19, 20), Loewi (26, 27), and Cannon (10, 11, 12, 13). Dale investigated the chemical transmission of the nervous impulse and eventually formulated the adrenergic-cholinergic theory of balance. Since his work, together with the fundamental investigations of Loewi and Cannon, have provided the principal background for the present concept of the control of visceral motility, these studies will be briefly reviewed.

THE CHOLINERGIC DIVISION OF THE AUTONOMIC NERVOUS SYSTEM

Elliott (16) in 1904 observed the similarity between the action of adrenalin and the stimulation of the "true" sympathetic nerves. Dixon (16) in 1906 argued that the parasympathetic nerves similarly release a chemical transmitter of their effects. The same year Howell (16) suggested that inhibition of the heart by vagus impulses is due to mobilization of potassium ions.

In 1921 Otto Loewi (26) stimulated the vagus to an isolated frog heart, removed the saline from the chamber, and something in the fluid inhibited a second frog heart. This proved the liberation of a specific chemical stimulator in the transmission of a peripheral autonomic stimulus. Later, Loewi (16) showed his "Vagusstoff" to be identical with acetylcholine in obtaining certain biological reactions.

Sir Henry Dale in 1933 (15) showed that when the sympathetic nerves of the sweat glands are stimulated, acetylcholine is produced. Therefore, he suggested a reclassification of the autonomic nervous system into adrenergic and cholinergic fibres, which on stimulation will produce adrenine or acetylcholine. Later work (16) has shown that all preganglionic fibres and most postganglionic fibres are cholinergic; the only adrenergic nerves are the postganglionic fibres of the "true" sympathetic nerves. Dale (17) believes that a propagated nervous impulse releases a wave of mobilization of potassium ions along a nerve fibre; this process arrives at the ending of a preganglionic fibre and there immediately liberates a small charge of acetylcholine, which causes the discharge of a new impulse, with perhaps a new wave of potassium mobilization passing along the postganglionic fibre. He believes that the excitatory impulse is actually transmitted across a synapse by the liberation of acetylcholine. Dale suggested in 1914 (18) that this is possible within the reaction time if acetylcholine were circulating in the blood in an inactive state, perhaps as choline, and when made active by its ester, is immediately inactivated by some substance, as cholinesterase. This suggestion was supported in 1936 in the course of further studies by Dale, Feldberg, and Vogt (19).

The majority of Dale's investigations have been confirmed and accepted by other students. Lehnartz (25) in 1936 found a similar mobilization of potassium ions could be produced by stimulation of the vagus with acetylcholine. Bureau (9) reports a detectable increase of potassium ions following electrical stimulation of frog muscle immersed in Ringer's solution.

If the nervous impulse is transmitted by acetylcholine, the origin of this substance is of importance. Recently considerable evidence has pointed to the presence of a precursor of acetylcholine in certain tissues. Dikshit (21) finds that

in the presence of eserine, acetylcholine is formed by thin slices of the brain of the dog and rabbit. Corteggiani (14) finds that the brain, spinal cord, nerves of many vertebrates, the vagus of the dog, and intestine of the hedgehog contain quantities of acetylcholine which can be liberated on heating. Pinotti (34) noted that the fibres of the vagus contain acetylcholine in the inactive state. These findings add weight to the conclusions of Brown and Feldberg (6) who believe acetylcholine is mobilized from a preformed store by immediate synthesis upon the arrival of the nervous impulse.

The theory of the production of acetylcholine as the substance of transmission of nervous impulses in muscle contraction also implies its extremely rapid disintegration. This extraordinary evanescence of action of acetylcholine was noted by Dale in 1914 (18) and he suggested at that time that it was probably hydrolyzed with great rapidity by an esterase in the blood. This has been confirmed by Marnay and Nachmansohn (28) who noted that the concentration of cholinesterase at the nerve end plates in the frog sartorius is many times that found in nerveless muscle tissue. This enables the muscle to split the acetylcholine liberated by nerve impulses during the refractory period. The chemical changes can occur with the rapidity necessary for the assumption of a chemical transmission of nerve impulses in such quickly reacting cells as fibres of voluntary muscle. However, owing to technical difficulties, it has not been possible to isolate cholinesterase, or to assay its activity at parasympathetic endings.

Clinicians who have used acetylcholine are struck by the uncertain and variable results following subcutaneous or intravenous injection of the substance. This is interpreted as due to the remarkable evanescence of acetylcholine, because of its rapid hydrolysis by the cholinesterase present in the blood and tissues. Fraser (22) found that subcutaneous injection of acetylcholine in man is usually without apparent effects, and even when introduced intravenously no effect is obtained if the blood is allowed to flow back into the syringe. It is therefore probable that following the arrival of the impulse at the nerve endings, acetylcholine is produced, transmits the effect of the impulse, and is almost immediately destroyed by the cholinesterase present locally in the tissue.

THE ADRENERGIC DIVISION OF THE AUTONOMIC NERVOUS SYSTEM

Cannon and Bacq (11) in 1931 elaborated Elliott's original finding and proved that any smooth muscle when affected by sympathetic impulses gives off a hormone, which when reinjected into the blood stream, will increase the blood pressure and heart rate. This hormone was named "Sympathin" and at first was thought to be identical with adrenalin.

However, Cannon and Rosenblueth (12), investigating this sympathetic substance in 1933, concluded that sympathin was not identical with adrenalin. Further they postulated the formation of two forms of sympathin. Sympathin E, which is formed when the action is excitatory, and Sympathin I, which is formed when the action is inhibitory. In addition they postulated a mediator M; thus the local effect is produced by the combination of M with E or I to form ME or MI.

It appears to be established that by whatever means the nervous impulse is transmitted, acetylcholine is produced at or near the end plate of the cholinergic nerve. The effect is then transmitted to the smooth muscle cell, and the acetylcholine is almost immediately hydrolyzed by cholinesterase. Sympathin is likewise produced at or near the end plate of the adrenergic nerves. Thus the activity of the organ involved by autonomic stimulation is the result of an interaction between acetylcholine, cholinesterase and sympathin. (Chart 1.)

Myerson (32) summarizes the opinion of many investigators when he calls attention to the inadequacy of even this concept of balance to explain all autonomic functions. However, investigators at present agree that visceral activity depends on a chemical balance. Therefore, the present concept of the activity of drugs on smooth muscle will be reviewed. (Chart 2.)

Acetylcholine, mecholyl (acetyl-beta-methylcholine-chloride), adrenalin, and benzedrine sulphate are believed to act directly on the smooth muscle fibre. Dale (17) noted a two phase reaction of acetylcholine following injection of the substance into smooth muscle. Brown and Harvey (7) repeated the arterial injection of acetylcholine into avian muscle. Raventos (35) injected acetylcholine into the tibialis artery of frogs. All these observers agreed that the action of acetylcholine was first at the end plate, and second on the muscle itself. Buchthal and Lindhard (8) noted that the thoracic muscle of the lizard

will contract when acetylcholine is applied directly to the muscle.

Elliott (16) in 1904 noted that after the sympathetic fibres had been cut and had degenerated, the structures previously innervated by them responded in a characteristic manner to adrenine. Nachmansohn (33) believes the action of adrenalin is on the muscle itself, independently of the nervous system, since adrenalin accelerated glycolysis in chopped muscle.

Finally, Cannon and Rosenblueth (13) showed that smooth muscle cells, completely deprived of their autonomic innervation, will react in the usual manner to adrenalin.

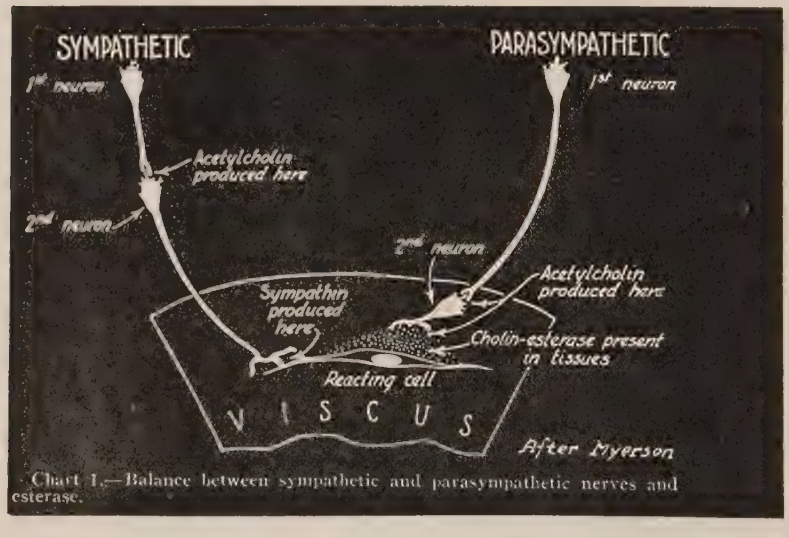


Chart 1.—Balance between sympathetic and parasympathetic nerves and esterase.

Bozler (4) draws attention to the protoplasmic connections existing between certain smooth muscle cells and states that after stimulation, an isolated strip of visceral smooth muscle acts as a single cell, following the "all or none" law. He believes that adrenalin decreases the excitability of the muscle; thus there is a resultant action of the muscle which appears to be due to the drug.

From these somewhat conflicting views, Myerson (32) has summarized the present concept of the action of drugs on smooth muscle. (Chart 2.) Atropine sulphate, physostigmine, and the commercial preparation of similar properties, Prostigmin, are believed to act in the region of the parasympathetic

end plates. Atropine in some unknown fashion blocks the action of acetylcholine. This it does, probably not by paralyzing the vagus, but by inhibiting the effect of acetylcholine on the cell of the effector organ either by a direct chemical block of acetylcholine or by enhancing the action of cholinesterase in such a fashion that acetylcholine is hydrolyzed more rapidly. In any case, by neutralizing or removing the cholinergic factor, atropine acts as a synergist to the adrenergic factor.

Prostigmin enhances the action of acetylcholine at the parasympathetic end plate. This is accomplished either by

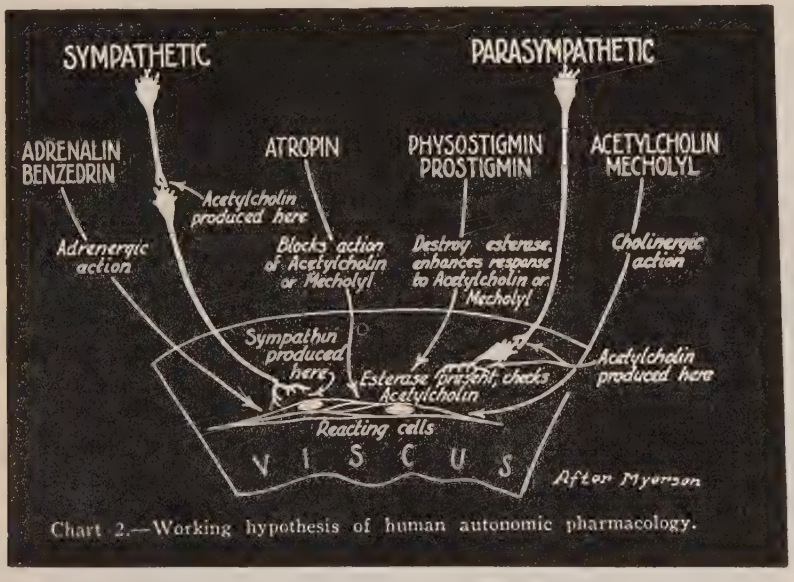


Chart 2.—Working hypothesis of human autonomic pharmacology.

Prostigmin entering into direct chemical union with acetylcholine so as to stabilize it, or by destroying esterase, thus delaying the hydrolyzation of acetylcholine.

This explanation of drug action, although it is accepted at present by many physiologists, does not adequately explain some of the clinical effects we have observed during investigation of the motor activity of the human stomach. In our investigations (37), Prostigmin administered alone inhibits the motility of the human stomach, but when administered in conjunction with atropine a motor effect is observed.

Recent work (5) indicates that drugs may have a more intricate action than is generally believed. The drugs whose

action is dependent upon the production of acetylcholine are believed to act simultaneously wherever acetylcholine is produced. Thus Prostigmin stabilizes the production of acetylcholine at the cholinergic end plate. However, it also stabilizes the production of acetylcholine at the sympathetic ganglion, when acetylcholine is produced to transmit the nerve impulse from the preganglionic to the postganglionic sympathetic fibre. Stabilization of the production of acetylcholine at the sympathetic ganglion would result in stimulation of the postganglionic sympathetic fibre, which would result in the production of a larger amount of sympathin at the adrenergic end plate. If this latter effect should overbalance the effect of stabilization of acetylcholine at the cholinergic end plate, the clinical effect on the stomach would be inhibition of motility following administration of Prostigmin.

In a similar fashion, atropine blocks the action of acetylcholine at the cholinergic end plate, but it also blocks the production of acetylcholine at the sympathetic ganglion. This would presumably prevent the transmission of the sympathetic impulse, so that a motor reaction could follow the administration of atropine. This is believed to explain the Prostigmin-atropine effect. Following administration of either Prostigmin or atropine, the motility of the human stomach is inhibited by enhancement of the adrenergic factor, but when both drugs are administered the chemical balance swings to the cholinergic side, so that clinically a motor effect is observed.

Recent investigations of the action of ephedrine cast some doubt on the similarity of its action with adrenalin and benzedrine. It may later be proved that ephedrine stabilizes the production of sympathin at the adrenergic end plate in the same manner that physostigmine stabilizes the production of acetylcholine at the cholinergic end plate (5). Further investigation on this subject is contemplated.

The action of morphine is not yet clear. Since this drug has several simultaneous sites of action, it is difficult to determine its autonomic pharmacology. An abundance of literature is to be found on the action of morphine, nevertheless, further investigation appears to be necessary. Clinically, Veach (36) has shown morphine to be predominantly motor to the human stomach. Weiss (38) reports that a number of investigators, Plant and Miller, Gruber and Robinson, Orr, Carlson and

others, have shown that morphine in ordinary doses increases the tone, amplitude and frequency of stomach contractions. Large doses stop peristalsis and decrease the tone, but increase the segmentary movements. In our investigations administration of morphine was followed by hypermotility of the stomach which increased the distress of postoperative "gas pains," late postoperative nausea, biliary colic, and pylorospasm due to obstructive duodenal ulcer. It seems probable that in respect to the stomach, morphine acts either as a synergist to acetylcholine, or inhibits the action of the esterases.

It is obvious that these theories do not explain all the details of autonomic pharmacology. Further investigation is necessary on the mechanism of the action of drugs on smooth muscle. It may be that after sympathin and cholinesterase are isolated, further light will be shed on this perplexing problem.

SUMMARY

According to the humoral theory, the activity of any organ involved by autonomic stimulation is the result of an interaction between acetylcholine, sympathin and the esterases. This concept of balance does not explain all autonomic functions. However, according to the present concept of the activity of drugs, acetylcholine acts on the smooth muscle cell, and is hydrolyzed by cholinesterase. Prostigmin enhances the action of acetylcholine, either by entering into direct chemical union with acetylcholine so as to stabilize it, or by destroying esterase, thus delaying hydrolyzation of acetylcholine. Atropine, in some fashion, blocks the action of acetylcholine. This it does, probably not by paralyzing the vagus, but by inhibiting the effect of acetylcholine on the cell of the effector organ. Loewi and Navratil (27) showed that although atropine inhibits the effects of vagal stimulation to the frog heart, it does not prevent the production of acetylcholine at the nerve endings. In any case, by neutralizing or removing the cholinergic factor, atropine acts as a synergist to the adrenergic factor. Benzedrine appears to act as adrenalin, directly on the smooth muscle cell.

Most drugs that affect the autonomic system simulate the effect of stimulation of the cholinergic or adrenergic nerves, although the mechanism of action in many cases is quite different. It is generally believed that the primary seat of action of certain drugs, such as adrenalin and acetylcholine, may be in the region of the end plate, directly on the smooth

muscle cell. In such a case, the action of the drug is independent of the nerve supply. Other drugs, such as atropine and physostigmine, are concerned with the nervous innervation of the muscle, and the customary action would appear to be dependent upon an intact nerve supply.

BIBLIOGRAPHY

(1) **Barron, Louis E.** and **Curtis, George M.** 1937. The Late Effects of Bilateral Resection of the Splanchnic Nerves on the Human Gastric Motor Mechanism. Am. J. Physiol. **120:** 356.

(2) **Barron, Louis E.** and **Curtis, George M.** 1937. Effect of Vagotomy on the Gastric Motor Mechanism of Man. Arch. Surg. **34:** 1132.

(3) **Barry, D. T.** 1932. The Functions of the Great Splanchnic Nerves. J. Physiol. **75:** 480.

(4) **Bozler, Emil.** 1938. Electric Stimulation and Conduction of Excitation in Smooth Muscle. Am. J. Physiol. **122:** 614.

(5) **Bozler, Emil.** Personal Communication to author.

(6) **Brown, G. L.** and **Feldberg, W.** 1936. The Acetylcholine Metabolism of a Sympathetic Ganglion. J. Physiol. **88:** 265.

(7) **Brown, G. L.** and **Harvey, A. M.** 1938. Reactions of Avian Muscle to Acetylcholine and Eserine. J. Physiol. **94:** 101.

(8) **Buchthal, Fritz** and **Lindhard, J.** 1937. Direct Application of Acetylcholine to Motor End Plates of Voluntary Muscle Fibres. J. Physiol. **90:** 82-P.

(9) **Bureau, V.** 1937. Recherches sur la libération de potassium par des muscles soumis à un electrotonus ainsi que par des muscles excités directement et indirectement. Arch internat. de Physiol. **45:** 40.

(10) **Cannon, W. B.** 1911. The Mechanical Factors of Digestion. London.

(11) **Cannon, W. B.** and **Bacq, Z. M.** 1931. A Hormone Produced by Sympathetic Action on Smooth Muscle. Am. J. Physiol. **96:** 392.

(12) **Cannon, W. B.** and **Rosenblueth, A.** 1933. Studies on the Conditions of Activity in Endocrine Organs: xxix—Sympathin E and Sympathin I. Am. J. Physiol. **104:** 557.

1935. A Comparison of the Effects of Sympathin and Adrenine on the Iris. Am. J. Physiol. **113:** 251.

(13) **Cannon, W. B.** and **Rosenblueth, A.** 1937. Autonomic Neuro-Effector Systems. Experimental Biology Monographs. Macmillan Pub. Co., New York.

(14) **Corteggiani, E.** 1937. Existence du complexe libérant l'acetylcholine sous l'influence de la chaleur dans divers organes de vertebrés. Compt. rend. Soc. de Biol. Paris, **125:** 949.

(15) **Dale, H. H.** 1933. Progress in Autopharmocology. Johns Hopkins Bulletin, **53:** 353, May.

(16) **Dale, H. H.** 1934. Chemical Transmission of the Effects of Nerve Impulses. Brit. Med. J. **1:** 835.

Elliott, T. R. 1904. Sympathetic Nerves and Adrenalin. Brit. J. Physiol. **31:** 20-P.

Howell. 1906. Am. J. Physiol. **15:** 14.

Dixon. 1906. Brit. Med. J. **2:** 1807.

Loewi, O. 1933. Pfluger's Arch. f. d. ges. Physiol., cited in this paper.

(17) **Dale, H. H.** 1937. Transmission of Nervous Effects by Acetylcholine. Harvey Lectures, **32:** 229.

(18) **Dale, H. H.** 1914. The Action of Certain Esters and Ethers of Choline and Their Relation to Muscarine. J. Pharmacol. and Exper. Therap. **6:** 147.

(19) **Dale, H. H.** and **Feldberg, W.** and **Vogt, M.** 1936. Release of Acetylcholine at Voluntary Motor Nerve Endings. J. Physiol. **86:** 353, May.

(20) **Dale, H. H.** and **Gaddum, J. H.** 1930. Reactions of Denervated Voluntary Muscle and Their Bearing on the Mode of Action of Parasympathetic and Related Nerves. J. Physiol. **70:** 109.

(21) **Dikshit, B. B.** 1938. Formation of Acetylcholine by Tissues. Pro. Soc. Biol. Chem. India, **3:** 63.
(22) **Fraser, Francis R.** 1938. The Clinical Aspects of the Transmission of the Effect of Nervous Impulses by Acetylcholine. Brit. Med. J. **1:** 4040, 1249, June.
(23) **Gayet, R., Minz, B.** and **Quivy, D.** 1937. Sur la libréation d'acetylcholine dans le sang veineux de l'estomac, de l'intestine, du pancreas par stimulation du nerf splanchnique. Compt. rend. Soc. Biol. **126:** 1138.
(24) **Harrison, J. S.** and **McSwiney, B. A.** 1936. The Chemical Transmitter of Motor Impulses to the Stomach. J. Physiol. 87: 79.
(25) **Lehnartz, E.** 1936. Potassium Ions and Vagus Inhibitions. J. Physiol. **86:** 37 P.
(26) **Loewi, Otto.** 1921. Ueber humorale Uebertragbarkeit der Herznervenwirkung: I. Mitteilung. Pfluger's Arch. f. d. ges. Physiol. **189:** 239.
(27) **Loewi, O.** and **Navratil, E.** 1924. Ueber humorale Uebertragbarkeit der Herznervenwirkung; VI. Mitteilung: Der Angriffspunkt des Atropine. Pfluger's Arch f. d. ges. Physiol. **206:** 123.
(28) **Marnay, A.** and **Nachmansohn, D.** 1938. Cholin-esterase in Voluntary Muscle. J. Physiol. **92:** 37.
(29) **McCrea, E. D.** 1925. The Nerves of the Stomach and Their Relation to Surgery. Brit. J. Surg. **13:** 621.
(30) **McSwiney, B. A.** 1931. Innervation of the Stomach. Physiol. Review, **11:** 478.
Hoffmeister, F. and **Schutz, E.** 1886. Arch. Exper. Path. u. Pharm. **20:** 7.
Cannon, W. B. 1898. Am. J. Physiol. **1:** 359.
Magnus, R. 1908. Pfluger's Arch. **122:** 210.
(31) **McSwiney, B. A.** and **Wadge, W. J.** 1928. Effects of Variations in Intensity and Frequency on the Contraction of the Stomach Obtained by Stimulation of the Vagus Nerve. J. Physiol. **65:** 350.
(32) **Myerson, Abraham.** 1938. Human Anatomic Pharmacology: xii. Theories and Results of Autonomic Drug Administration. J. A. M. A. **110:** 101.
(33) **Nachmansohn, D.** 1937. Action des substances sympathominétiques et parasympathominétiques sur les processus chimiques fournissant l'énergie de la contraction musculaire; action de l'adrénalin sur le muscle heché. Bull. Soc. Chim. Biol. Paris, **19:** 453.
(34) **Pinotti, O.** 1937. Acetylcholine of Cholinergized Nerves. Bull. Soc. ital. Biol. sperim; **12:** 765.
(35) **Raventos, J.** 1937. The Effects of Arterial Injections of Drugs on the Frog's Gastronemius. J. Physiol: **90:** 8, P.
(36) **Veach, Harry O.** 1937. The Antagonistic Action of Morphine and Atropine on the Human Stomach. J. Pharm. & Exper. Therap: **61:** 230.
(37) **Veach, Harry O., Lauer, B. R., and James, A. G.** 1938. Effects of Prostigmin and Atropine on the Human Stomach. J. Pharm. & Exper. Therap: **62:** 422.
(38) **Weiss, Soma.** 1938. Certain Biologic Action and Therapeutic Effect of Morphine and of Related Compounds. Am. J. Med. Sci.: **196:** 743.

Microbes and Men

Considerable objection can be raised to the title of this book if its purpose is to point out the importance of the microbes to human welfare. The all too prevalent idea that bacteria are important only insofar as they produce disease is one the biologist would like dispelled. Fortunately the author has written a book broader in viewpoint than the title would indicate. The book is well-balanced and accurate, the illustrations well-chosen, and the subject matter ably presented. It contains a good glossary and has an index. Since it is designed for the general reader and not for use as a text the jargon of the bacteriologist is avoided as much as possible. I am afraid, however, that the general reader may still find it difficult to appreciate much of the discussion. Somehow the book lacks fire.—*J. M. Birkeland.*

Man Against Microbes, by Joseph W. Bigger. 304 pp. New York, the Macmillan Co. 1939. $2.50.

THE DEVELOPMENTAL HISTORY OF GERMARIA IN PARTHENOGENETIC FEMALE APHIDS[1]

CHESTER A. LAWSON
Wittenberg College

INTRODUCTION

That germaria play a significant role in determination of differential features between gamic female and parthenogenetic female ovarioles of the aphid *Macrosiphum solanifolii* was suggested by Lawson (1939b). The ovarioles of both types of females consist of a tubular vitellarium on the end of which is attached a spherical germarium containing nurse cells and germ cells. The germ cells in both types of ovarioles descend from the germarium into the vitellarium where development occurs, but the development of germ cells in gamic female ovarioles differs from the development of germ cells in parthenogenetic female ovarioles. In the vitellarium of a gamic female ovariole the eggs grow large by the accumulation of much yolk, presumably undergo meiosis and require fertilization and deposition before embryonic development can occur. In the vitellarium of the parthenogenetic female ovariole the germ cells are stimulated to develop parthenogenetically into embryos which are born alive upon reaching the proper stage of development. The fundamental difference between the two types of ovarioles is the difference between the two types of germ cells that develop within the ovarioles. These germ cells are produced by the germaria and, according to the theory proposed by Lawson, each germarium determines the subsequent development that its germ cells shall undergo. Other differences between parthenogenetic female and gamic female ovarioles are supposedly secondary to the germ cell difference and are determined also by the original differentiation between germaria.

If the germarial theory is correct it also should explain the production of (1) structures other than ovarioles which differentiate gamic and parthenogenetic females, (2) aphids intermediate between gamic and parthenogenetic females, (3) winged

[1]This investigation was aided by a grant from the Research Fund of the Ohio Academy of Science.

and wingless parthenogenetic females, and (4) aphids intermediate between winged and wingless parthenogenetic females. These forms are interrelated in such a way that variations in the same mechanism must be responsible for the production of all.

The first step in a study of the relation of germaria to determination of various aphid types is an understanding of the developmental history of the germaria in the parthenogenetic female aphid. This paper is an attempt to lay such a foundation.

FIRST APPEARANCE OF GERMARIAL CELLS

There is a stage in the development of a parthenogenetic female aphid embryo shortly after the germ band is formed when one end of the embryo opens to allow "symbionts" or "mycetocytes" to enter. The symbionts fill the entire central cavity of the blastula shaped embryo with the exception of a small space immediately dorsad of the germ band. Lying in this space between the germ band and the symbionts is a group of cells whose descendants make up the germaria (fig. 1). Each of these cells has a large nucleus with a very thin layer of cytoplasm around it. The nucleus contains a prominent nucleolus and either a number of chromosomes that appear split longitudinally in preparation for mitotic division or a thick, heavily staining late prophase strand. The cells are larger than any other cells in the embryo except those cells that become hosts for the symbionts. These host cells can be distinguished from the germarial cells by virtue of their containing chromatin in a very thin lightly staining spireme.

The group of cells that have been designated "germarial cells" could also be called "germ cells" in contrast to the somatic cells which make up the rest of the embryo. However, as all of the original group of cells do not become reproductive cells it is thought best to use "germarial cells" for the cells in early stages of development and to reserve "germ cells" for the actual reproductive cells that differentiate later.

IDENTIFICATION OF GERMARIAL CELLS IN EARLY EMBRYONIC STAGES

During the early stages of development which precede revolution of the embryo the germarial cells lie in a compact group at the posterior end of the embryo, surrounded by a thin epithelial membrane. The cells can be recognized easily by their size, which is usually greater than adjacent somatic cells, and by the nature of their nuclei which usually contain chromatin in various prophase stages. A further mark of recognition is the position of the germarial cells in relation to the symbionts. These symbiotic cells collect at the posterior end of the embryo during early developmental stages. Lying next to them and sometimes partially surrounded by them are the germarial cells.

EARLY DEVELOPMENT OF THE GERMARIAL CELLS

Though the germarial cells are isolated somewhat from the somatic cells of the embryo, they go through a series of developmental stages which parallels the development of the soma. A series of mitotic divisions occurs in the germarial cells between the germ band stage and the revolution of the embryo. Metaphase stages are occasionally observed while prophase stages are common. During this period of mitotic division the germarial cells are evidently segregated into groups for whenever metaphase stages are observed they occur in groups of adjacent cells only and not in the entire group of cells. The cells not in metaphase exhibit the more common prophase stages.

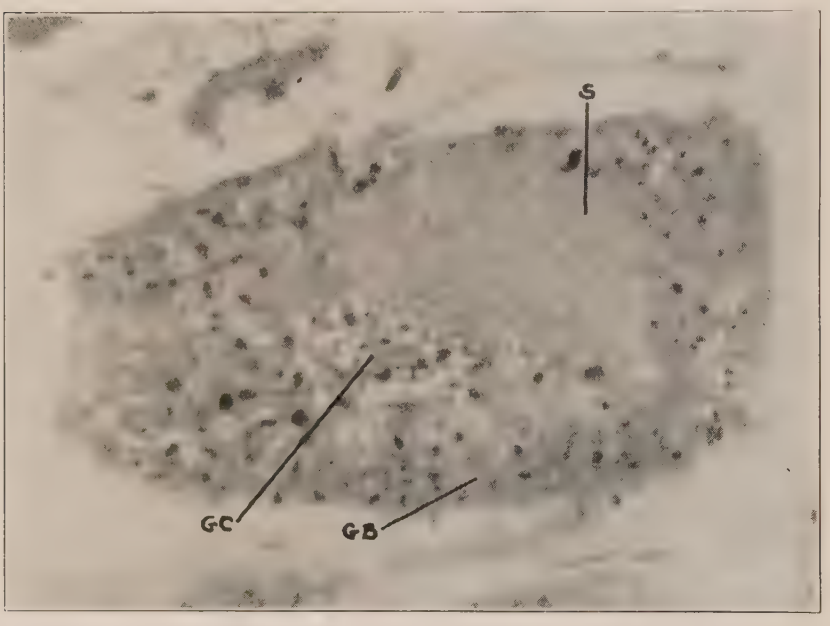


Fig. 1. Longitudinal section through an aphid embryo at stage of development of germ band. GB—germ band, GC—germarial cells, S—symbionts.

FORMATION OF GERMARIA

A change in the germarial cells that is evident at least as early as the formation of appendage buds in the soma is an increase in the cytoplasm of each cell. This cytoplasm does not form evenly around the nucleus but concentrates at one side forming a blunt, cone-shaped tail. At about the same time that the cytoplasmic cone is formed on each cell, the cells are arranged more or less loosely into a number of spherical groups. In each sphere of cells the nucleus of each cell lies near the periphery and the cytoplasmic cone lies between the nucleus and the center of the sphere. In a cross section of such a group the nuclei form a ring in the center of which is a circular area of cytoplasm made up of

several cytoplasmic cones lying side by side. Metaphase stages of cell division have been observed in these spheres of germarial cells. Either shortly before or during the revolution of the embryo each group of germarial cells becomes surrounded by a thin epithelial membrane and henceforth can be called a germarium.

POSITION OF THE GERMARIA

The position of the germaria relative to the rest of the embryo is changed during the revolution of the embryo. Prior to this event the germaria, or in early stages the germarial cells, are found at the posterior

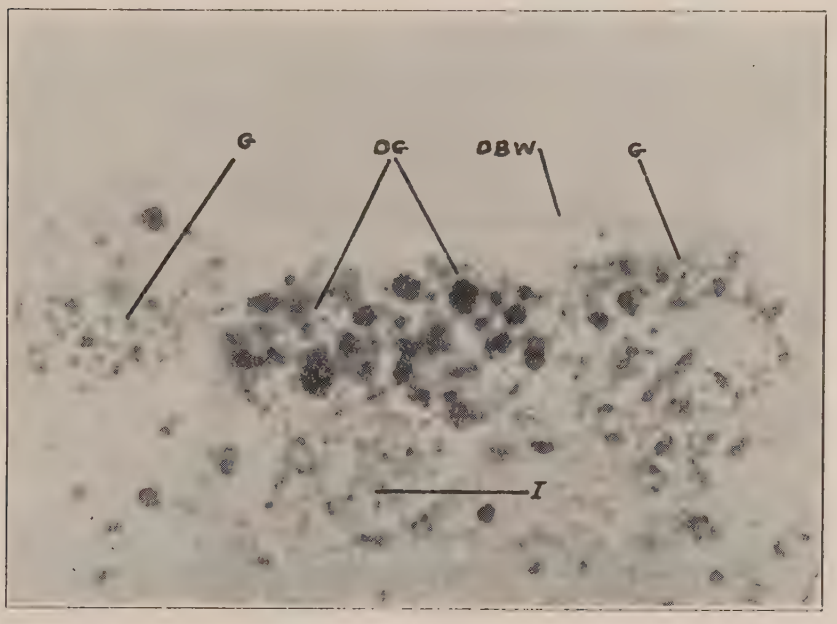


Fig. 2. Cross section through dorsal half of aphid embryo at a stage before dorsal body wall is fully developed. DBW—dorsal body wall, DG—degenerating germaria, G—germarium, I—intestine.

end of the embryo in close contact with the symbionts and in a sense outside of the body of the embryo. After the revolution of the embryo the germaria and the symbionts are located within the newly formed abdominal cavity. At this time the embryo has developed a head, thorax, appendages and a body wall. The body wall, however, is incomplete on the dorsal side of the abdomen, so that here the abdominal cavity opens directly to the outside. The germaria lie just within this opening forming a plate-like group of cells which extends from one lateral side of the abdomen to the other and from near the anterior end of the abdomen to near the posterior end. Immediately ventrad of the germaria are the symbionts which fill the greater part of the abdominal cavity.

DEGENERATION OF MID-DORSAL GERMARIA

Several groups of germaria which lie in the mid-dorsal region of the abdominal cavity degenerate after revolution of the embryo and before the dorsal body wall closes (fig. 2). During this degeneration the cells round up, become smaller than other germarial cells and stain an intense black with iron-hematoxylin. These cells are completely gone by the time the dorsal body wall closes.

After the degeneration of the mid-dorsal germaria two sets of germaria remain, one on each lateral side of the abdominal cavity. One group usually contains five germaria and the other contains four or occasionally five. This is the number and arrangement of germaria in older more fully developed embryos.

DIFFERENTIATION OF NURSE CELLS AND GERM CELLS

The germarial cells differentiate into two types of cells, nurse cells and germ cells, sometime during embryonic development between the germ band stage and closure of the abdominal wall. The exact time that this differentiation takes place is difficult to ascertain because of the similarity between the two types of cells. A distinction can be made after the germaria are fully formed, for the nurse cells then are grouped in a sphere, while the germ cells lie at the posterior end of the germarium between the ball of nurse cells and the epithelial covering of the germarium. Prior to the formation of the germaria the nuclei of the cells occasionally exhibit different prophase configurations, but this does not differentiate the two types of cells. The cytoplasm of the germarial cells becomes cone shaped before germaria are fully formed, and it was thought that the presence of such cones on certain cells would identify them as nurse cells, while the absence of such cones on other cells would identify them as germ cells. No such distinction could be made with certainty, though it may exist. Differing sizes of cells as a criterion is equally uncertain, for nurse cells sometimes vary in size within the same germarium and, also, in different germaria.

DEVELOPMENT OF THE OVARIOLES

After the formation of the germaria the epithelial covering of each germarium grows back as a small cellular tube in a posteriad-ventrad direction toward the region where the vagina later develops. These backward growing cellular tubes are the ovarioles or more precisely, the vitellarial region of the ovarioles. There are two groups of ovarioles, one for each lateral group of germaria. The ovarioles in each group unite a short distance behind the germaria to continue toward the vaginal region as a single tube which becomes the oviduct of the adult. As there are two groups of germaria, and two groups of ovarioles there are likewise two oviducts. In adult anatomy the ovariole includes the epithelial covering of the germarium and the tube that leads from the germarium to the oviduct, while the vitellarium refers only to that part of the ovariole that leads from the germarium to the oviduct.

PARTHENOGENETIC DEVELOPMENT OF GERM CELLS

Following the establishment of the ovarioles, the germ cells begin parthenogenetic development. This development begins at about the same time that the first faint indication of pigment appears in the eyes of the embryo. Usually one germ cell in each germarium begins to grow through an increase in the amount of cytoplasmic material (fig. 3). The probable source of this additional material is the ball of nurse cells, for with the beginning of germ cell growth, a stream of substance is evident extending from the center of the ball of nurse cells into the growing germ cells. This stream maintains contact with the oöcyte

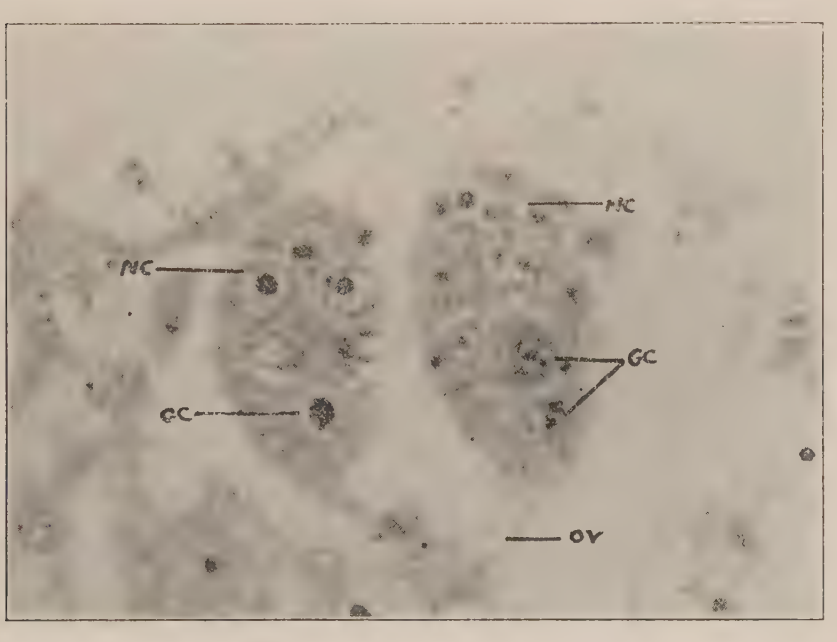


Fig. 3. Cross section through dorsal half of aphid embryo showing a longitudinal section through two germaria. GC—germ cell, NC—nurse cell, OV—ovariole (vitellarium).

until cleavage is well under way. The exact nature of this substance is uncertain, though a nutrient function is indicated. In a previous publication (Lawson 1939b) the secreted substance was called "yolk" and the stream or thread extending from the nurse cells to the growing germ cell was called a "yolk-stream." This choice of terms may be unfortunate for there is no certainty that the substance is yolk. Growth of the germ cell continues within the germarium until the germ cell has about tripled its size when it moves downward into the vitellarium. This germ cell or oöcyte, as it may now be called, continues to increase in size, throws off a polar body, and begins cleavage. After cleavage begins another germ cell grows, slips into the vitellarium and goes

through the same developmental stages as the first cell. A third cell follows the second into the vitellarium before the embryo is born, so that in the oldest embryos each vitellarium commonly contains one growing oöcyte, one egg in early cleavage and one in late cleavage.

POSSIBLE SIGNIFICANCE OF GERMARIAL ACTIVITY

The determination of the winged or wingless condition in the adult aphid occurs before birth (Shull 1928). Hence, if the germarial theory is to have any application to wing determination there must be some event in the embryonic development of germaria that directly affects wing development. The initial stimulation of germ cells to parthenogenetic development may be the visible consequence of such an event.

Shull (1938) has shown that wings begin to develop sometime after pigmentation begins in the eyes of the embryo, but before one-fourth of the ommatidia are pigmented. The first indications of germ cell growth appears at the same time that the first faint traces of eye pigment can be seen. Thus, it may be concluded that germ cells are stimulated before wing differentiation begins. Shull (1938) has estimated that wing determination occurs 10 or 12 hours before wing differentiation. That germ cell stimulation likewise occurs 10 or 12 hours before wing differentiation cannot be said, but that it occurs very near this time is possible.

A variation occurs in the time of initial stimulation of germ cells in the various germaria in the same embryo. Numerous cases have been found where two or three vitellaria contain oöcytes while the other vitellaria in the same embryo have none, and in some cases where all of the ovarioles show germ cell activity some of the oöcytes are more advanced in development than others. This variation supports the theory that germaria are determined, develop and function independently of one another, and, furthermore, it suggests a possible mechanism for the germarial control of wing determination.

To correlate germarial activity with wing determination it is necessary to know, at the time of initial germ cell stimulation, whether or not a given embryo is to be winged or wingless. This could not be determined in the embryos used in this study, so the problem must wait until such information concerning the embryos can be obtained. The use of the constant and intermittent light technique described by Shull (1938) should enable us to get this information.

SUMMARY

The developmental history of the germaria in parthenogenetic female aphids is described beginning with the appearance of the germarial cells in the blastula. The germarial cells are arranged in groups, each of which becomes a germarium. All of the germaria that are formed do not persist, for those lying in the mid-dorsal abdominal region degenerate. The remaining germaria form two groups, one on each dorso-lateral side of the abdominal cavity. Within each germarium the cells

differentiate into nurse cells and germ cells. An ovariole grows out from each germarium and connects to the oviduct, and into the vitellarium of each ovariole the germ cells descend, grow and undergo cleavage. The growth of the germ cells is aided by a substance secreted by the nurse cells. The time when germ cells are first stimulated to parthenogenetic development approximates the time when wing determination takes place and the suggestion is made that the determination of the winged or wingless condition in the adult aphid may be controlled by the germaria.

BIBLIOGRAPHY

Lawson, C. A. 1939b. The significance of germaria in differentiation of ovarioles in female aphids. Biol. Bull., 77: 135.

Shull, A. F. 1928. Duration of light and the wings of the aphid Macrosiphum solanifolii. Roux' Arch. 113, H. 1: 210.

Shull, A. F. 1938. Time of determination and time of differentiation of aphid wings. Am. Nat., 72: 170.

The Bionomics of Entomophagous Insects

Prof. W. V. Balduf of the University of Illinois has recently published a second volume on the bionomics of entomophagous insects. Part II covers in considerable detail the widely scattered information on the bionomics of entomophagous species of Lepidoptera, Trichoptera, Mecoptera and Neuroptera. One only needs to read the first three chapters (over 100 pages) devoted to predacious Lepidoptera to appreciate the amount of reading and compilation work the author must have done to assemble such interesting and valuable information. An examination of the excellent bibliographies shows that the subject matter was found in numerous and obscure publications in several languages.

A compilation of this type is of outstanding value to anyone interested in biological control or the biology of predacious insects. As valuable as this book will prove to be, most entomologists will look upon it as a library reference book. It is unfortunate that unique books of this character are not purchased more extensively by persons interested in the biology of insects. The reviewer knows from experience that the production of special books, where the edition does not exceed five hundred copies, usually results in a financial loss to the author.

This book consists of 384 8½ x 11 inch lithoprinted pages, equal to 600 pages of an ordinary size book. It contains 228 excellent figures, 21 tables of information and a complete index. The reviewer hopes that a sufficient number of copies will be sold so that the author will not suffer a financial loss. He would like to see the author prepare in the future one or more volumes dealing with entomophagous Diptera and Hemiptera.—*A. Peterson.*

The Bionomics of Entomophagous Insects, Part II, by W. V. Balduf, 384 8½ x 11 inch lithoprinted pages, 228 figures. St. Louis, John S. Swift and Co. 1939. $7.50.

Histology

In this recently revised pocket-sized volume the elementary facts and principles of the whole field of micro-anatomy including the nervous system are presented with little explanatory and illustrative material, and with little reference to histo-physiology. Actually, the work is an epitome of histo-anatomy. The student preparing for an examination should find it useful for rapidly reviewing the subject matter of a course in micro-anatomy.—**R. A. Knouff.**

Aids to Histology (4th ed.), by Alfred Goodall. Baltimore, William Wood and Co. 1938. $1.25.

THE EMBRYOLOGY AND LARVAL DEVELOPMENT OF THE GOLDFISH (CARASSIUS AURATUS L.) FROM LAKE ERIE

HELEN I. BATTLE
Department of Zoology, University of Western Ontario

INTRODUCTION

Osburn (1901) noted that the common goldfish (*Carassius auratus* L.) had escaped from cultivation in some parts of Ohio and as early as 1888 was reported by Henshall as "not rare in the canal basin near Elmwood, Hamilton County." The species has become quite common in Lake Erie in shallow parts, especially bays and creek mouths (Greeley, 1928). It has been reported by fishermen off the north shore at Port Stanley where it is said to attain a length of 14 to 15 inches. The description of its early development has not, however, been included by Mrs. Fish (1932) probably because it is not an indigenous species.

The goldfish and other Cyprinidae have long been used by geneticists, and also by embryologists, for specialized studies in fish development. However, other than the account by Khan (1929) and the illustrations by Dr. F. J. Myers in the volume by Innes (1936) an adequate description of the general features of its embryonic and larval development is lacking. The following account is an attempt to fill this gap since the goldfish is becoming increasingly important not only from the standpoint of the ornamental fish trade, and as an experimental test animal, but also because of its ability to adapt itself successfully to environmental conditions in Lake Erie.

MATERIALS AND METHODS

All of the eggs for this study were obtained from two sources, Squaw Harbor, South Bass Island, Ohio, in the summer of 1938, and the Moore Water Gardens, Port Stanley, Ontario, in the spring of 1939. The latter provided stages from spawning through early cleavage, since in the breeding cages it was possible to obtain eggs very shortly after they had been deposited on the roots or leaves of any convenient floating aquatic plant such as *Potamogeton*, *Valisneria*, or *Chara*.

All observations were made on living material which was

later fixed in Bouin's Fluid and preserved in 70% alcohol for future reference. The eggs were brought into the laboratory while still attached to water plants and small sections of the latter bearing eggs were transferred to finger bowls containing lake water. To simulate natural conditions some were hung over the float in bottles lowered to a depth of six to twelve inches, while others kept in a semi-dark room were subjected to strong sunlight for short periods daily. No discernible differences were evident between those reared under the two conditions.

Larvae after the first five to seven days were kept in an aquarium in aerated water. Food consisted of plankton taken by a fine net from the adjacent region of the lake, and finely ground rice flour.

SPAWNING

Fearnon (1931) states that goldfish begin breeding in their second year and while they may continue to reproduce for six or seven years they yield the maximum number of eggs in their third and fourth years. Khan (1929) found that spawning usually begins early in the spring and occurs at frequent intervals from April to August over a period from 7 a. m. to 10 a. m. Innes (1936) noted that spawning usually starts at daybreak and lasts till mid-afternoon. From early spring it may be repeated every few weeks until early August but the first spawn of the season is the largest. At Squaw Harbor eggs were obtained in segmentation stages about 8 a. m. to 9 a. m. as late as August 17th, 1938. The capsules of the eggs are of a mucilaginous character and adhere readily to aquatic plants to which they are usually attached singly, rarely in twos or threes and at intervals of one-half to one inch.

EMBRYONIC DEVELOPMENT

Characteristics of the egg

The eggs of the goldfish are spherical pale cream-colored globules, 1.25 to 1.46 mm. in diameter, and slightly flattened along the margin of attachment. When first laid the whole surface is adhesive, but this quality is lost as soon as they have become "water hardened" and attached to aquatic plants. Like other fish eggs, those of this species are telolecithal, the heavier yolk lying beneath the cap-like whitish protoplasmic blastodisc which covers the upper surface (fig. 1). A narrow perivitelline space (.1 mm.) separates the yolk sphere from the heavy structureless egg capsule. The cream-colored yolk is rather unique since it appears to be coarsely granular with a rather dense fluid matrix

containing sparsely scattered transparent oil droplets (.01 to .05 mm. in diameter). The latter have a tendency to disappear during later stages of development.

Period of Incubation

Khan (1929) found the hatching period to vary from forty-six to fifty-four hours at 84° F. Innes (1936) reports a hatching period of from four to fourteen days according to temperature. At 70° to 75° F. five to seven days are required. No attempt was made to rear the eggs from Squaw Harbor at a constant temperature, but those kept in the laboratory with an air temperature ranging from 18.5° C. to 29.5° C. hatched in three to four days. Eggs placed in containers and reared in the lake water which was subject to less radical temperature variations (24° C. to 28° C.) required only sixty-four to seventy-two hours. At Port Stanley, following the late cleavage stages, eggs were subjected to a constant temperature of 25° C. and hatching took place in seventy-six hours.

Cleavage Stages

A few minutes after fertilization the blastodisc contracts and forms a white dome on the upper surface of the yolk (fig. 1). In approximately half an hour the first cleavage furrow, a vertical meridional one, appears (fig. 2) forming two large and approximately equal blastomeres. Fifteen minutes later the second cleavage furrow also a vertical meridional one appears at right angles to the first (fig. 3). Following this, cleavage becomes irregular and in two hours' time the blastoderm is composed of a mass of relatively small but distinct cells (fig. 4). After four hours' development the cells have become relatively smaller owing to rapid cell division, and the margin of the blastoderm has begun to extend slightly farther over the yolk (fig. 5). In each cell the cytoplasm shows a tendency to radiate from the nucleus.

Investment of the yolk by the blastoderm

The blastoderm becomes thinner along its free edge and now commences to grow ventrally to extend over the yolk sphere. By seven hours' of incubation, it has reached the equator of the egg (fig. 6). The advancing rim of the blastoderm stands slightly above the surface level of the yolk. In the nine hours' stage the blastoderm has completely encircled the yolk with the exception of a small spherical blastopore surrounding a plug of yolk.

Differentiation of the Embryo

Ten hours.—The surface view gives no indication of the embryonic axis aside from a slightly opaque area of undifferentiated tissue passing anteriorly along one radius from the margin of the blastopore.

Eleven to twelve hours.—The axis of the fish embryo is visible as a narrow but rather high transparent ridge extending forward from the blastopore, nearly encircling the yolk (figs. 7 and 8), and bounded on either side by the lateral margins of the embryonic shield. The future head region appears as a flat somewhat oval expansion. By twelve

hours three to four mesodermal somites have appeared and the notochord is differentiated as a narrow band of cells lying next to the yolk substance.

(Drawings by camera lucida)

Fig. 1. Recently fertilized egg.
Fig. 2. First cleavage division. 30 mins.
Fig. 3. Second cleavage division. 45 mins.
Fig. 4. Many-celled blastoderm. 2 hours.
Fig. 5. Advanced blastoderm. 4 hours.
Fig. 6. Yolk mass half overgrown by blastoderm. 7 hours.
Fig. 7. Early embryo, lateral aspect. 11 to 12 hours.
Fig. 8. Early embryo, dorsal aspect. 11 to 12 hours.
Fig. 9. Later embryo with optic vesicles, dorsal view. 15 hours.
Fig. 10. Later embryo with optic vesicles, ventral view. 15 hours.
Fig. 11. Embryo of 18 somites. 17 hours.
Fig. 12. Embryo of 25 somites. 24 to 27 hours lateral aspect.
Fig. 13. Embryo of 25 somites, dorsal aspect. 24 to 27 hours.
Fig. 14. Embryo of 32 somites. 45 hours.
Fig. 15. Embryo of 32 somites removed from egg capsule. 45 hours.
Fig. 16. Advanced embryo, preparatory to hatching. 65 hours.

Fifteen hours.—Although the blastopore has not yet closed, marked changes have taken place in the anterior axial region (figs. 9 and 10) of the embryo. The brain is clearly visible and the optic evaginations are somewhat oval extending posteriorly from the primary cerebral lobe. Eight to ten somites are present. The embryonic body appears as a thickened ridge and passes by a thin narrow margin to the portion of the blastoderm now one or two cells in thickness, which spreads over the yolk.

Seventeen hours.—The tail reaches almost around to the anterior limit of the head (fig. 11), but the embryo is still adherent to the yolk sac at both ends. Eighteen somites have been differentiated. Auditory vesicles as well as olfactory pits have appeared. The notochord extends as a solid rod of cells from the auditory vesicle to the undifferentiated caudal mass.

Twenty-four to twenty-seven hours. The embryonic body has increased in length, the tail process reaching almost to the anterior limit of the head. Both the head and tail are freed from the yolk surface. A narrow fin fold surrounds the tail and extends forward dorsally to the mid body region (figs. 12 and 13). Distinct contractile movements are evident. Twenty-five somites have been differentiated, but no pigment is visible. The brain is composed of three cerebral lobes, the posterior (rhombencephalon) being elongate with a diamond-shaped ventricle. The optic vesicle has been converted into an optic cup into which the lens has sunken. The notochord is visible as a vacuolated rod extending from the level of the auditory vesicle to the undifferentiated tissue in the core of the tail. The heart has appeared on the anterior surface of the yolk sac as a flattened tube and is pulsating irregularly. The ducts of Cuvier traverse the yolk, passing ventrolaterally from the level of the first few mesodermal somites to the posterior end of the heart. The dorsal aorta is also visible in the trunk region.

Forty-five to fifty hours.—The embryo now forms more than a complete circle around the circumference of the yolk. Its tail lies either to the right or left of the head and is often bent at an angle across the front of the latter. It undergoes rhythmic movements and swims feebly when the capsule is removed with a needle. Small scattered melanophores have appeared on the outer surface of the eye, larger stellate ones over the head and the yolk sac and along the dorsal portion of the body and the primitive intestine (figs. 14 and 15). The brain lobes have increased in size. The yolk sac which has been spherical now consists of an anterior spherical to oval division and a posterior cylindrical portion which terminates at the anus. The pectoral fins appear as fleshy folds lying over the yolk sac at the level of the auditory vesicle. The typical teleostean circulation has been set up at this time. Size measurements are as follows: Total length (head-tail), 2.5; standard length, 2.4; length to vent, 2.0; length of head, 0.70; snout, 0.10; diameter of eye, 0.25; greatest depth before vent, 1.0 millimeters. Myomeres 20 to 22 to vent plus 10 to 12 behind.

Sixty to sixty-five hours.—The embryo has increased considerably in size occupying most of the perivitelline space. Rhythmic movements

occur freely within the egg capsule (fig. 16). Heavy stellate melanophores are massed over the head, the yolk sac, along the dorsolateral musculature, and ventrally over the region of the intestine and ventral musculature. The eye has increased in size and has become densely pigmented. The auditory vesicle is now enlarged and thin-walled, containing two otoliths and the rudiments of semi-circular canals. The dorsal fin fold extends forward to the level of the first somite. The pectoral fins are now free from the yolk surface and are composed of a fleshy base bearing a membranous tip. Removed from the capsule the embryo now resembles the newly hatched larva. Total length 4.4; standard length, 4.2; length to vent 2.9; length of head, 0.78; snout, 0.17; diameter of eye, 0.3; greatest depth before vent, 0.95 millimeters. Myomeres, 21 to 22 to vent plus 11 to 12 behind.

DEVELOPMENT OF THE LARVA AND POST LARVA

Newly-hatched larva (fig. 17.) The larva frees itself by violent lashing movements of the tail which eventually rupture the egg capsule. Total length, 4.5; standard length, 4.3; length to vent, 3.0; length of head, 0.8; snout, 0.17; diameter of eye, 0.3; greatest depth before vent, 0.95 millimeters. Myomeres, 21 to 22 to vent plus 11 to 12 behind.

Pigmentation consists of stellate melanophores located around the jaws, on the dorsal surface of the head, and the whole dorsal aspect anteriorly to the caudal fin. The pigment spots are fewer on the sides of the head and body at the level of the lateral line. There is a heavy subsurface mass of them dorsal to the gill arches, and a double to triple series on the dorsal surface of the intestine extending beyond the vent to the tip of the notochord. The yolk sac bears large scattered melanophores more especially anteriorly. Swimming movements are somewhat restricted owing to the mass of yolk material. The larva shows a positive thigmotropism, adhering to the aquarium walls or any fragments of plants. The heart is differentiating into chambers although it is still almost vertical in position at the anterior end of the yolk sac. Five aortic arches are present. The continuous median fin fold with its preanal portion has already been adequately described by Grimm (1937). The cerebral hemispheres, pineal body, mid brain (optic lobes), cerebellum and medulla oblongata are all clearly distinguishable.

5.8 millimeter stage. (fig. 18). Age 1½ to 2½ days. Total length, 5.8; standard length, 5.2; length to vent, 4.1; length of head, 1.3; snout, 0.3; diameter of eye, 0.35; greatest depth before vent, 0.85 millimeters. Myomeres, 22 to vent plus 12 behind. The embryo shows a distinct reduction in the size of the yolk sac which has now become almost tubular due to its greater absorption anteriorly.

Pigmentation resembles that of the recently hatched larva except for an increase in density especially in the eye, and the appearance of heavy masses of yellow pigment spots (xanthophores) along the dorsal musculature and over the head. The mouth has opened and an opercular membrane is growing posteriorly over the gills. The air bladder is partially inflated. The gut is a simple tube dilated to some extent just behind the air bladder. The heart owing to the absorption of the yolk material now assumes an axis parallel with the median longitudinal

axis of the body, by the dorsal migration of the posterior end in an arc of approximately 30°.

6.8 millimeter stage (fig. 19). Age 7 to 8 days. Total length, 6.8; standard length, 6.1; length to vent, 4.7; length of head, 1.45; snout, 0.3; diameter of eye, 0.52; greatest depth before vent, 1.0 millimeters. Myomeres, 22 to vent plus 12 behind. The most conspicuous change, while the fish grows from 5.8 millimeters to 6.8 millimeters, takes place in the absorption of the yolk material, which is now represented by a few granules midway between the pectoral fin and the anus. The mouth has enlarged and the lower jaw moves rhythmically. The posterior end of the notochord has become bent upward slightly and rudiments of caudal fin rays are evident in the fin fold among the melanophores below the curved notochord. The outline of the fin itself however remains somewhat truncate. Fin rays are not evident elsewhere although a concentration of mesenchyme occurs at the region of the future dorsal. The operculum is well developed and a few gill filaments protrude beyond its posterior margin. Melanophores on the dorsal surface of the head are beginning to round up and others have appeared on the ventral margin of the operculum and on the dorsal surface of the air bladder. Dense yellow pigment is present all over the surface of the body. The lateral line has become more distinct. The alimentary canal is a straight tube enlarged anteriorly. The liver, reddish yellow in color, appears as a triangular mass on the ventral surface immediately posterior to the heart.

7.9 millimeter stage (fig. 20). Age 15 to 18 days. Total length, 7.9; standard length, 7.0; length to vent, 5.3; length of head, 1.65; snout, 0.35; diameter of eye, 0.71; greatest depth before vent, 1.20 millimeters. Myomeres, 22 to vent plus 12 behind. Melanophores about the head region have rounded up but over the rest of the body are stellate. A new row has appeared marking the lateral line. The yellow pigmentation is heavy and the general body surface is taking on an iridescent appearance. The caudal fin has forked into dorsal and ventral lobes supported by unbranched fin rays. The dorsal fin region is marked by an elevation of the fin fold and the appearance of elongated melanophores among the embryonic rays. The anal fin is indicated by an accumulation of mesenchyme and melanophores in the median fin fold which has become slightly lobed a short distance behind the anus. Embryonic fin rays have appeared in the pectorals. The otoliths have become almost as large as the lens of the eye. The operculum completely covers the gills. The air bladder is partially divided into two chambers. Minute spherical partially pigmented elevations are present on the lips.

9.4 millimeter stage (fig. 21). Age 22 to 23 days. Total length, 9.4; standard length, 8.3; length to vent, 6.4; length of head, 2.4; snout, 0.52; diameter of eye, 0.85; greatest depth before vent, 1.7 millimeters. Myomeres, 22 to vent plus 12 behind. The organism is becoming noticeably more opaque and has taken on a greenish yellow to fawn coloration. Aside from the margin of the operculum and adjacent to the fin rays, the melanophores are no longer stellate but contracted into spherical spots which are concentrated chiefly above the lateral line. The caudal fin shows little advancement over the 7.9 mm. stage, but the dorsal now

bears nine true rays. The median fin fold is beginning to disappear dorsally between the dorsal and caudal fins and between the caudal and anal fins ventrally. The anal and pectoral fins have developed distinct rays. The pelvic fins have appeared as minute lateral fleshy protuberances from the body wall midway between the pectorals and the anus.

FIGURE 17

FIGURE 18

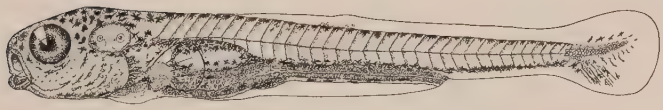


FIGURE 19

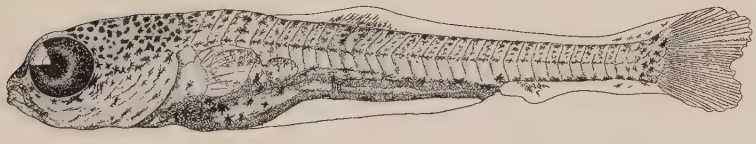


FIGURE 20

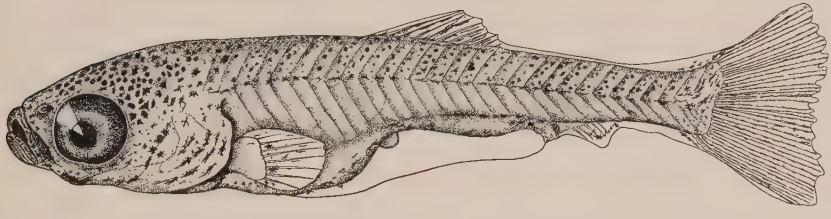


FIGURE 21

(Drawings by camera lucida)

Fig. 17. Newly-hatched larva. 4.5 mm.
Fig. 18. 5.8 mm. stage. 1+ to 2+ days.
Fig. 19. 6.8 mm. stage. 7 to 8 days.
Fig. 20. 7.9 mm. stage. 15 to 18 days.
Fig. 21. 9.4 mm. stage. 22 to 23 days.

11.6 millimeter stage. Age 37 days. Total length, 11.6; standard length, 9.6; length to vent, 8.2; length of head, 3.1; snout, 0.68; diameter of eye, 0.95; greatest depth before vent, 2.3 millimeters. Myomeres,

22 to vent plus 12 behind. Differences from the preceding stage are principally in the greater development of the pelvic fins, in which there is an indication of rays. The preanal fin fold is reduced anteriorly, and the caudal rays are commencing to branch. The body has become more opaque, greenish yellow and iridescent in appearance.

15.7 millimeter stage. Approximate age 9 weeks. Total length, 15.7; standard length, 12.6; length to vent, 10.0; length of head, 4.0; snout, 0.8; diameter of eye, 1.4; greatest depth before vent, 4.5 millimeters. The fish now has acquired essentially the form and shape of the adult and varies from olive green or brown to orange red in color. Pigmentation is general. The body is fully scaled. Segmentation and branching of some of the fin rays may continue for some time (Grimm, 1937).

TABLE I

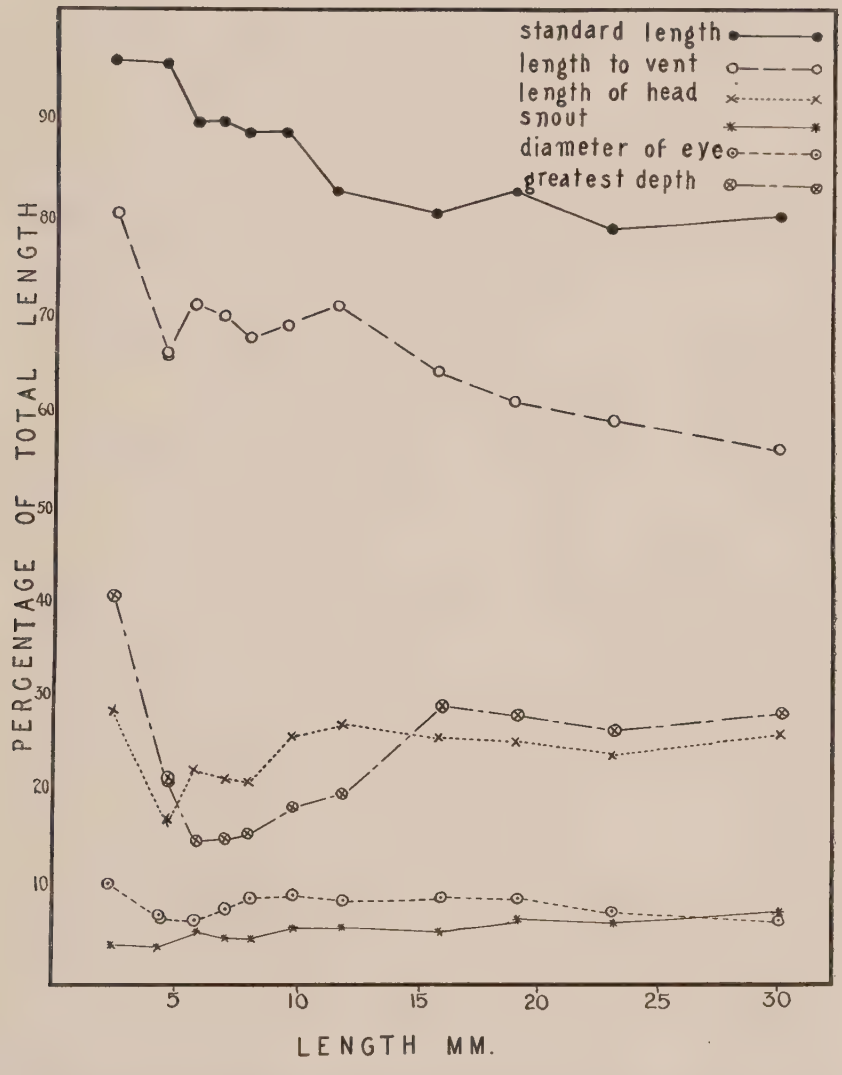
MEASUREMENTS OF GOLDFISH THROUGH PREHATCHING, LARVAL, AND YOUNG STAGES

Age	Total Length, mm.	Standard Length, mm.	Length to Vent, mm.	Length of Head, mm.	Snout, mm.	Diameter of Eye, mm.	Greatest Depth before Vent, mm.
Hours:							
45–50	2.5	2.4	2.0	0.70	0.10	0.25	1.00
60–65	4.4	4.2	2.9	0.78	0.17	0.30	0.95
76*	4.5	4.3	3.0	0.80	0.17	0.30	0.95
Days							
1½–2½	5.8	5.2	4.1	1.30	0.30	0.35	0.85
7–8	6.8	6.1	4.7	1.45	0.30	0.52	1.00
15–18	7.9	7.0	5.3	1.65	0.35	0.71	1.20
22–23	9.4	8.3	6.4	2.40	0.52	0.85	1.70
37	11.6	9.6	8.2	3.10	0.68	0.95	2.30
Weeks							
9	15.7	12.6	10.0	4.00	0.80	1.40	4.50
?	19.0	15.7	11.5	4.80	1.30	1.60	5.30
?	23.0	18.0	13.5	5.50	1.50	1.70	6.00
?	30.0	24.0	17.0	7.80	2.10	2.00	8.50

*Newly hatched larvae.

Table I gives the measurements of goldfish from 2.5 mm. (45 to 50 hours incubation) to a length of 30.0 mm. attained at the end of approximately 3½ to 4 months in an outdoor aquarium. All figures are average measurements of six specimens. The accompanying graph (graph 1) indicates the standard length, length to vent, length of head, greatest depth anterior to vent, snout, and diameter of eye, as percentages of the total length. The large initial drop of the greatest depth ratio is attributed to the absorption of the yolk substance. It will be observed

that for specimens from 15.7 mm. the percentage lines are almost parallel to one another, which would seem to indicate that only relatively minor if any changes in proportion are occurring.



Graph 1. The relation between the total length of the prehatching, larval and young goldfish, and the standard length, length to vent, length of head, length of snout, diameter of eye, greatest depth before vent, expressed as percentages of the total length.

SUMMARY

This paper is the result of a preliminary study of the salient features of the embryology of the goldfish (*Carassius auratus* L.). It is based upon material obtained from Lake Erie and reared at the Stone Laboratory and at Port Stanley.

The goldfish is typical of the teleosts in its general development. The eggs which adhere to floating aquatic plants are 1.25 to 1.46 mm. in diameter and hatch in seventy-six hours at 25° C. The first cleavage takes place one-half hour after fertilization, and in nine hours the blastoderm has completely encircled the yolk with the exception of a small spherical blastopore. In twelve hours four somites are visible, in fifteen hours eight to ten. Two hours later the tail reached almost to the head, and eighteen somites have been differentiated. At twenty-four hours the somite count is twenty-five, the brain is distinctly divided into three primary lobes and the heart is beating rhythmically. Further development to hatching involves pigmentation by melanophores, enlargement of all the embryonic structures, and an elongation of the yolk sac posteriorly.

At hatching the larva is 4.5 millimeters in length, and restricted in movement by the weight of the yolk sac. By one and one-half to two and one-half days, a length of 5.8 millimeters is attained, and the yolk sac has been reduced to a narrow tubular band. Yellow pigmentation has appeared, and the standard myomere count of 22 to vent plus 12 behind is attained. The air bladder is partially inflated. At seven to eight days (6.8 millimeter stage), the yolk material has practically all disappeared. Rudiments of caudal fin rays are evident. The operculum practically covers the gills and the liver is present as a triangular mass at the anterior end of the body cavity.

The 7.9 millimeter stage (age 15 to 18 days) shows increased yellow pigmentation and reduction of melanophores to blackish spheres in the head region. The air bladder has divided into two chambers. By 22 to 23 days (9.4 millimeter stage) the organism is becoming more opaque. The pelvic fin buds have just appeared and fin rays are present in all the other fins. Pigmentation is concentrated above the lateral line.

At approximately nine weeks (15.7 millimeters) the fish has acquires scales, pigmentation is general, and the body bears essentially the adult characteristics.

ACKNOWLEDGMENTS

The author wishes to express appreciation to a number of persons, whose co-operation has made this paper possible. Thanks are due Dr. T. H. Langlois for placing all facilities at the Franz Theodore Stone Laboratory, Put-in-Bay, Ohio, at the writer's disposal and to Mr. M. Moore of the Moore Water Gardens, Port Stanley, Ont., for much valuable material. Special thanks are due Dr. R. C. Osburn for his assistance and constructive criticism at all times.

BIBLIOGRAPHY

Fearnow, E. G. Goldfish, Their care in small aquaria and ponds. U. S. Fishery Circ. No. 6. 16 pp. Oct. 1931.

Fish, Marie Poland. Contributions to the early life histories of sixty-two species of fishes from Lake Erie and its tributary waters. Bull. U. S. Bur. Fish. Vol. XLVII. pp. 292–398. 1932.

Greeley, J. R. A biological survey of the Erie-Niagara system. VI. Fishes of the Erie-Niagara watershed. Supp. 18th Annual Report, Conservation Dept., State of New York. pp. 150–179. 1928.

Grimm, Wilbur W. The development of the fins of the goldfish (*Carassius auratus*). Abstract of Doctor's Dissertations No. 23. Ohio State University. 1937.

Innes, W. T. The complete aquarium book. (15th edition). Innes Publishing Company, Phila., Pa. p. 212. 1936.

Khan, M. Hamid. Early stages in the development of the goldfish. (*Carassius auratus*). Jour. Bombay Nat. Hist. Soc. Vol. XXXIII, pp. 614–617. 1929.

Osburn, Raymond C. The Fishes of Ohio. Ohio State Academy of Science. Special Paper No. 4. 1901.

Animals in Winter

This field-book contains a large amount of general and specific information on where and how animals spent the cold months of the year. Such information is widely scattered in the literature and this book makes it accessible. Also the author includes many original observations. Although primarily intended as a guide for outdoor use, much fundamental ecology and many life histories are included. Indeed, the book is not the least bit superficial; zoologists as well as amateur naturalists can benefit by a careful reading of the text and examination of the numerous illustrations, which are good and often new. This book is a vivid example of true natural history; it is not a catalog of oddities. The animals are alive and the kind you will find, the events are real, and the subject matter is new. Who can miss examining this book, even though he proceeds to read it at the expense of prearranged tasks?—*Carl Venard.*

Field Book of Animals in Winter, by Ann H. Morgan, 528 pages; 283 drawings and photographs, including four plates in color by Roger T. Peterson. New York, G. P. Putnam's Sons. 1939. $3.50.

Edison

Edison's Open Door, written by Alfred O. Tate, his private secretary over a long period of years serves to give the reader an intimate glimpse into the activities of the Wizard of Menlo Park. The book is not a biography in the usual orthodox sense, but is rather a book of informal reminiscences from the great inventor's life. The book is entrancingly interesting from cover to cover, each page crowded with incidents and details in the development of many of the devices which have made our present day life what it is. An evening with this volume is an evening well spent.—*H. H. Nielsen.*

Edison's Open Door, by Alfred O. Tate, 320 pp. New York, E. P. Dutton & Co. 1938. $3.00.

THE ALIMENTARY CANAL OF DIPLOTAXIS LIBERTA GERM. (SCARABAEIDAE: COLEOPTERA)

CLYDE ROOSEVELT JONES
1616 Hunter Avenue, Columbus Ohio

This article is a morphological and histological study of the alimentary canal of the scarabaeid beetle *Diplotaxis liberta* Germ.

The beetle was collected at Westbury, Long Island, New York, while the author was working for the United States Entomological Sub-laboratory. The species is a night flier and about sixty specimens were collected from around street lights and fixed in Kahle's solution, then preserved in seventy-five per cent alcohol. Dr. E. A. Chapin, Taxonomic Investigator, Bureau of Entomology, United States Department of Agriculture, later identified it as *Diplotaxis liberta* Germ. The beetle is about twelve millimeters long and from reddish brown to black in color. According to Fall (7) it is restricted mainly to the Atlantic Coast States from Massachusetts to Georgia and is occasionally taken west of the Appalachian Mountains.

The author wishes to express his appreciation for the suggestions, criticisms and assistance so freely given by Dr. C. H. Kennedy, and for the helpful comments of many of his fellow students.

GROSS ANATOMY OF THE DIGESTIVE TRACT

General discussion.—The alimentary canal is divided into three main divisions as determined by the embryonic origin. The anterior portion (stomodaeum or fore-intestine) and the posterior portion (proctodaeum and hind-intestine) arise as ectodermal invaginations of the body wall. The epithelium of the mesenteron (ventriculus or mid-intestine) is formed by the proliferation of rings of cells in the endodermal tissue, eventually connecting the fore- and the hind-intestines.

Though there are some variations that occur, the different divisions and sub-divisions will usually be found to lie as follows: the fore-intestine (plate I, fig. 1) passes posteriorly along the median axis to the union of the prothorax and the mesothorax where it joins the mid-intestine. The mid-intestine continues posteriorly along the median axis for about one-third of its length; then it curves to the left and downward, then laterally across the abdominal cavity, making approximately two full spiral curves before looping anteriorly and then posteriorly inside of the second and smaller curve. The union of the mid-

intestine or stomach and the hind-intestine occurs at about the fourth abdominal segment.

The hind-intestine then passes caudally to about the fifth abdominal segment where it enlarges and curves dorsally, then to the right and slightly downward, tapering down to a smaller portion of the alimentary canal. It then curves dorsally and to the left passing over the last curve and a little to the left of the median axis, where it then curves to the right and posteriorly to the anus. The alimentary canal in toto is about thirty-nine and five-tenths millimeters long.

The Fore-Intestine

The fore-intestine is the shortest division of the alimentary canal. It comprises about one-ninth of the total length. The pharynx appears as a short dilated portion posterior to the mouth. The oesophagus connects the pharynx and crop and is a short narrow tube. (See plate I, fig. 1.)

The *crop* (CR) comprises the posterior two-thirds of the fore-intestine. The crop is dilated and is much larger than the oesophagus.

The *oesophageal valve* (OES. V) marks the division of the fore- and mid-intestine by a slight constriction. It is not visible externally.

The Mid-Intestine

The mid-intestine (M. I.) is the largest and longest division of the alimentary canal and comprises about five-ninths of its total length. There are no essential differences in the structures at the two ends, but there is a gradual tapering off in the size from the anterior to the posterior end. The anterior portion is about twice as large in cross-section as the posterior and the size varies with different individuals, depending upon the amount of food present in the canal. Both portions have numerous small crypts upon their outer surfaces.

The Hind-Intestine

The divisions of the hind-intestine are: anterior ileum; posterior ileum; colon; rectum and anus; to the anterior end are attached the malpighian tubules.

The *pyloric valve* (P. V.) forms the junction of the mid-intestine with the hind-intestine and is marked by a slight constriction. The pyloric valve, being internal, is not apparent externally.

The *malpighian tubules* (M. T.) are four in number and are attached separately to the canal, two anterior to the pyloric valve and two posterior to the valve. The two anterior ones are attached on each of the ventro-lateral sides whereas the posterior two empty close together into a bladder on the dorsal side of the anterior end of the ileum. The dorsal tubules are nearly twice as large in diameter as the other two. All are very long, and coiled around close to the canal and extend to the oesophageal valve where they turn posteriorly and terminate with their tips lying upon the mid-intestinal wall.

The *bladder* (BL.) attaches to the dorsal side of the anterior ileum just behind the pyloric valve.

The *anterior ileum* (A. IL.) begins at the division of the mid- and hind-intestine, is the shortest of the four divisions of the intestine, and

tapers off to be the narrowest section of the canal. The caudal or small end of the anterior ileum appears to be constricted at its junction with the posterior ileum but no valve was observed.

The *posterior ileum* (P. IL.) abruptly enlarges following its junction with the anterior ileum; then it tapers off gradually to the size of the colon. Through the thin layers of muscle tissue may be seen numerous folds in the epithelial layer of cells. See plate I, fig. 1, P. IL.

The *colon* (CO.) connects the posterior ileum with the rectum. It is a small uniform tube with well developed muscles on its outer walls. It merges gradually into the *rectum* (REC.) which gradually dilates for a distance, then contracts to the anus. The rectum lies in the region of the sixth, seventh and eighth abdominal segments. As on the colon, the circular and longitudinal muscles are well developed and visible externally.

HISTOLOGICAL STRUCTURE OF THE ALIMENTARY CANAL

The Fore-Intestine.—In general the structure of the fore-intestine is the same throughout though there may be differences in detail.

The innermost layer is the intima, a chitinous layer which is homologous with the cuticula of the body wall. It is continuous throughout the fore-intestine and is a non-cellular homogenous structure. The intima is secreted by the hypodermal epithelial cells and forms a rather thick layer in the mouth (buccal cavity) and pharynx; then it gradually gets thinner as it passes caudally; upon reaching the oesophageal valve it thickens again. In the region of the pharynx it forms spines that protrude inward and caudally but they do not encircle the canal, being found on the folds in the lateral and dorsal sides of the canal. (See fig. 2, plate I.) The intima stains a deep green with Fast Green F. C. F. stain.

The epithelial layer (EPI.) of hypodermal cells just outside of the intima is composed of irregular flattened cells. Their cell walls are apparent but no basement membrane is visible. The cells are of the same character throughout the length of the fore-intestine.

Immediately outside of the epithelium are found the longitudinal muscles (L. M.) which vary in number from isolated strands to layers two or three strands in thickness. In the area of the pharynx and oesophagus they are most numerous and are distributed well around the canal as shown in a cross section. (See fig. 2, plate I.) They gradually become fewer in number towards the crop where only a few isolated strands occur.

The circular muscles (C. M.) lie outside of the longitudinal muscles. Here again, as with the longitudinal muscles, they are the thickest in the region of the oesophagus, being three to four strands thick, gradually diminishing in thickness caudad to one or two thin strands in the region of the crop and then thickening to two or three strands near the oesophageal valve. On the outermost part of the fore-intestine traces of a peritoneal membrane (P. M., fig. 6) composed of connective tissue can be observed here and there, though it is largely obscured by the fatty tissue that surrounds this region of the canal.

The oesophageal valve (fig. 5) which marks the inner division of the junction of the fore- and hind-intestine extends slightly down into the

lumen of the ventriculus as a fold. The valve is composed of an epithelium of hypodermal cells. The cells at the beginning of the fold are of a flattened, irregular type. They soon change to long columnar cells as they extend along the innermost side of the fold; then they gradually decrease in size on the reflexed side; and at the end of the reflexed layer they are cuboidal and join with the cells of the mid-intestine. The intima which continues around the valve disappears at the base of the reflexed layer of cells.

In this region there is a complete reversal of the position of the circular and longitudinal muscles. The circular muscles shift to become the inner layer of muscle fibers on the ventriculus. In the depression formed by the reflexed fold of the valve are numerous circular muscles (C. M.) which serve to close the valve. (fig. 5, plate I.)

Histology of the Mid-Intestine.—A histological study of the mid-intestine shows the following tissues to be much the same in size and structures throughout: (1) epithelium of endoderm cells supported by a basement membrane; (2) circular muscles; (3) longitudinal muscles; (4) "peritoneal" membrane of connective tissue. (fig. 6, plate I.)

The cells of the epithelium vary in shape and size during different periods of the feeding habits of the animal. They may be cuboidal after a period of secretion or they may be columnar during the period of resting, due to the accumulation of the digestive fluids within them. Shortly after feeding, the cells that are filled with the digestive fluid give off the fluid by the cell wall bursting, when the whole, or part, of the contents is expelled into the lumen of the intestine. This is termed the holocrine type of secretion. The burst cells in the holocrine type of secretion are replaced by other cells that are regenerated in the regeneration cell layer at their base or from crypts. These crypts (CRY., fig. 6) are nests of digestive cells which have sunken below both the epithelium and the circular muscles. Within the crypts are developed new cells that replace some of the cells that burst during secretion. The bases of the epithelial cells rest upon a basement membrane. The epithelial layer is generally folded to a greater or lesser degree throughout the length of the canal. Fig. 12 shows the abundance of the crypts as indicated by the distribution of their openings into the stomach.

Immediately outside of the basement membrane lie the circular muscles (C. M., fig. 6) in a layer one strand thick which completely encircle the canal by the interlacing of their ends, when viewed in a cross-section. Still further outward is a single layer of numerous isolated strands of longitudinal muscles. These appear to be connected in places by a thin connective tissue which is probably the peritoneal membrane. The relative position of the longitudinal and circular muscles about the mid-intestine is the reverse of that in the fore- and hind-intestine.

Surrounding the food within the mid-intestine is a very thin structureless peritrophic membrane (PER. M.). It is thought to be secreted by cells at the base of the reflexed layer of cells of the cardiac or oesophageal valve. Its function may be to protect the delicate inner ends of the epithelial cells from the coarse foods.

Histology of the Hind-Intestine.—The origin of the hind-intestine is similar to that of the fore-intestine, being formed from the invagination

of the body wall. The pyloric valve (fig. 7) and the two forward malpighian tubules mark the union of the anterior and with the ventriculus.

A microscopic study of the canal shows the following layers present: (1) an intima; (2) an epithelium of hypodermal cells resting on a basement membrane; (3) longitudinal muscles; (4) circular muscles; (5) "peritoneal" membrane of connective tissue. (figs. 9 and 10, plate II.)

The malpighian tubules (M. T.) are of ectodermal origin, although the two anterior ones appear to open into the ventriculus. They are made up of large irregular cells with oval or spherical nuclei. (figs. 3 and 4, plate I). The number of cells vary from four or five to thirteen or fourteen in a cross-section. The larger sections near the proximal end contain the greater number of cells. The cells secrete fluids by the merocrine type of secretion. Surrounding the mouth of the tubes and extending up in them a short way is a delicate layer of intima, whereas the rest of the inner surface is lined with a striated border. In some sections a striation also appears near the basal side of the cell. The outer surface of the tube is covered with a thin layer of connective tissue.

The pyloric valve (fig. 7) marks the greater part of the internal junction of the mid- and hind-intestine, and consists of a definite folding of the epithelial hypodermal layer into the lumen of the anterior ileum. The cells become extremely elongated and extend out as irregular fan-shaped structures in longitudinal section. The valve consists of two distinct forms of fan-like structure, the central and lateral structure being somewhat flattened and extending downward into the lumen, while the dorsal structure is semicircular with one edge extending into the lumen and the other into the bladder. (fig. 7, plate II.)

The inner surface of the valve is lined with a thin layer of intima, which begins with the cuboidal cells on the anterior side of the valve and extends throughout the ileum in numerous folds. External to the valve and within its folds are a number of circular muscles (C. M., fig. 7) whose function is probably that of closing the valve. A few longitudinal muscles are scattered here and there among them. As at the junction of the fore- and mid-intestine, the muscles here again are reversed in their relative positions.

The bladder (fig. 7) is probably an evagination of the dorsal surface of the ileum, adjacent and caudal to the pyloric valve. The layer of intima lines the inner wall of the bladder. The cells of the epithelium are very irregular, flattened and small. On the outer surface are scattered thin strands of longitudinal and circular muscles. (fig. 7, plate II.)

In the remainder of the ileum (P. IL., fig. 1; and figs. 8 and 11) the layer of epithelium is greatly folded and composed of small irregular shaped cells. Immediately outside of the cell layer are a few isolated strands of longitudinal muscles; outside of these are the circular muscles which vary in thickness from one to two strands in the anterior region and to three or four strands in the posterior region. Outside of the circular muscles are isolated strands of a second layer of longitudinal muscles and a thin layer of peritoneal connective tissue.

The posterior ileum (P. IL., fig. 1) which lies between the anterior ileum and the colon is probably the most outstanding of all the divisions of the canal. The epithelial layer of very irregular cells lies in deep

crosswise folds that are broken by short lengthwise folds; these folds extend into the lumen of the canal, leaving only a small passage for the food throughout the ileum. (See figs. 8 and 11.) These small separate folds are termed by some workers "papillate processes." Surrounding each of them is a thick non-cellular mass of substance that stains a deep green, with Fast Green F. C. F. stain. (fig. 8, plate II, posterior ileum.)

Spines were observed upon the intima at the anterior end of the ileum. The irregularity of the cells probably aids in holding the mass in place. Particles of food sometimes appear between the folds. (fig. 11, plate II, posterior ileum.) Immediately outside of the epithelium is a poorly developed layer of circular muscles. These may be seen at the end of the folds in a cross-section. (fig. 11, plate II, anterior ileum.)

The longitudinal muscles form the outer layer of muscles and are well developed but very thin.

The intima at the anterior end of the ileum is thickened and contains a few spines, while that lining the inner surface of the folds is very delicate and is free of spines.

The ileum gradually merges into the colon. In the colon the intima is of moderate thickness. The circular muscles are the inner layer of muscles. They are well developed and are one to two strands thick. The longitudinal muscle layer is poorly developed and lies as isolated strands and small groups of several strands outside of the circular muscles.

The colon and rectum are very much alike in structure and no difference other than that of size appears. The intima and epithelium are continuous throughout. The epithelium of hypodermal cells that extends throughout the rectum (figs. 9 and 10) is divided into six main longitudinal and several subordinate folds. The outer ends of each of the six main folds are attached to the circular muscles by muscle fiber. The nuclei here, as everywhere else in the canal, are clear and relatively large.

The circular muscles which are in a single layer in the colon gradually become more numerous after they merge with the rectum, until near its center they form a layer four to five strands thick (fig. 10). This then gradually thins down to a layer one strand thick and just anterior to the anus thickens again into a layer nine or ten strands thick. The outer longitudinal muscles are isolated strands. Strands of "peritoneal" membrane of connective tissue appear here and there, all along the outer surface of the hind-intestine. (figs. 9 and 10, plate II.)

SUMMARY

The alimentary canal of *Diplotaxis liberta* Germ. is morphologically divided into three main divisions, namely: fore-intestine, mid-intestine, and hind-intestine. These main divisions are further divided into: Fore-intestine; Pharynx, oesophageal valve. Mid-intestine: entirely stomach. Hind-intestine: Phloric valve, malpighian tubules, bladder, anterior and posterior ileum, colon, and rectum.

The following layers are present: Fore-intestine: Intima, epithelium of hypodermal cells resting on a basement membrane, longitudinal muscles, circular muscles, and "peritoneal" membrane of connective tissue. Mid-intestine: Peritrophic membrane, epithelium of endodern cells and regenerative cells resting on a basement membrane, circular muscles, longitudinal muscles and "peritoneal" membrane. Hind-intestine: Intima, epithelium of hypodermal cells resting on a basement membrane, inner longitudinal muscles (in anterior end), circular muscles, outer longitudinal muscles and "peritoneal" membrane.

The malpighian tubules are four in number and enter separately into the canal, two anterior to the pyloric valve and two posterior to the valve. The anterior tubules are attached to the ventro-lateral sides and empty directly into the canal; whereas the posterior ones empty into a bladder on the dorsal side which has a common opening into the canal. The bladder is an invagination of the epithelium of the ileum.

The papillate processes of the posterior ileum are folds of the epithelium that project down into the lumen. These folds are covered with a non-cellular mass of material.

BIBLIOGRAPHY

(1) **Auten, Mary.** 1933. The Structure of the Digestive System in *Bolitotherus cornutus*. Ohio Jour. Sci. Vol. 33, pp. 280–287, 2 Pls.
(2) **Becton, Edward M., Jr.** 1930. The Alimentary Canal of *Phanaeus vindex* Macl. (Scarabaeidae). Ohio Jour. Sci., Vol. 30, pp. 315–323, 2 Pls.
(3) **Bigham, John T.** 1930. The Alimentary Canal of *Asaphes memnonius* Hbst. Ohio Jour. Sci., Vol. 30, pp. 386–395, 2 Pls.
(4) **Brubaker, Ross W.** 1934. The Alimentary Tract of *Penthe pimelia* Fabr. (Coleoptera: Dacnidae.) Ohio Jour. Sci., Vol. 34, pp. 46–56, 2 Pls.
(5) **Burgess, Emory D.** 1932. A comparison of the Alimentary canals of the active and hibernating adults of the Mexican Bean Beetle *Epilachna corrupta* Muls. Ohio Jour. Sci., Vol. 32, pp. 249–261, 2 Pls.
(6) **Davidson, Ralph H.** 1931. The Alimentary Canal of *Criocerus asparagi* Linn. Ohio Jour. Sci., Vol. 31, pp. 396–405, 2 Pls.
(7) **Fall, H. C.** 1909. Revision of the Species of Diplotaxis of the United States. Trans. Amer. Ent. Soc., Vol. 35, pp. 1–98, 1 Pl.
(8) **Fletcher, Fred W.** 1929. The Alimentary Canal of *Phyllophaga gracilis* Burm. Ohio Jour. Sci., Vol. 29, pp. 109–119, 2 Pls.
(9) **Landis, B. J.** 1936. Alimentary Canal and Malpighian Tubules of *Cerato magilla fusilabris* Muls. Ann. Ent. Soc. Amer. 29(1): 15–27, 4 Pls. 1936.
(10) **Lewis, H. C.** 1926. The Alimentary Canal of Passalus. Ohio Jour. Sci., Vol. 26, pp. 11–24, 2 Pls.
(11) **Miller, Warren C.** 1931. The Alimentary Canal of *Meracantha contracta* Beauv. Ohio Jour. Sci., Vol. 31, pp. 143–156.
(12) **Schaefer, Paul E.** 1931. The Alimentary Canal of *Sphaeroderus pitidicollis* Chev. variety schaumi Chaudoir. Ohio Jour. Sci., Vol. 31, pp. 406–415, 3 Pls.
(13) **Swingle, M. C.** 1930. Anatomy and Physiology of the Digestive Tract of the Japanese Beetle. Jour. Agr. Res., Vol. 41, pp. 181–196.
(14) **Talbot, Mary.** 1928. The Structure of the Digestive System in *Creophilus villisis*. Ohio Jour. Sci., Vol. 28, pp. 261–268, 2 Pls.
(15) **Woods, W. C.** 1918. The Alimentary Canal of *Altica bimarginata* Say (Coleoptera.) Ann. Ent. Soc. Amer., Vol. 11, pp. 283–314.

EXPLANATION OF PLATES

Plate I

Fig. 1. Dorsal view showing gross dissection of the alimentary canal of *Diplotaxis liberta* Germ.
Fig. 2. Cross-section through the oesophagus.
Fig. 3. Cross-section through malpighian tubule near the distal end.
Fig. 4. Cross-section through malpighian tubule near the proximal end.
Fig. 5. Longitudinal section through the oesophageal valve.
Fig. 6. Cross-section through the mid-intestine.

Plate II

Fig. 7. Longitudinal section through the pyloric valve, showing bladder and entrance of malpighian tubule.
Fig. 8. Cross-section through the posterior ileum.
Fig. 9. Cross-section through the rectum near the anterior end, showing the relationship of the muscles.
Fig. 10. Cross-section through the rectum near the middle.
Fig. 11. Portion of a cross-section of the posterior ileum enlarged, showing the papillate processes.
Fig. 12. Diagram of a portion of the external wall of the mid-intestine greatly enlarged, showing the number of crypts per unit area.

KEY TO ABBREVIATIONS

A. IL.....Anterior Ileum
BL.....Bladder
B. M.....Basement Membrane
C. M.....Circular Muscles
CO.....Colon
CR.....Crop
CRY.....Crypt
EPI.....Epithelium
FD.....Food
F. T.....Fat tissue
INT.....Intima
L. M.....Longitudinal Muscle
LU.....Lumen
M. I.....Mid-intestine
M. T.....Malpighian tubule
OES.....Oesophagus
OES. V...Oesophageal Valve
PA. PR...Papillate process
PER. M...Peritrophic membrane
HP.....Pharynx
P. IL.....Posterior ileum
P. M.....Peritoneal membrane
P. V.....Pyloric Valve
REC.....Rectum
REG. C...Regenerative cell
S. B.....Striated Border
SP.....Spines

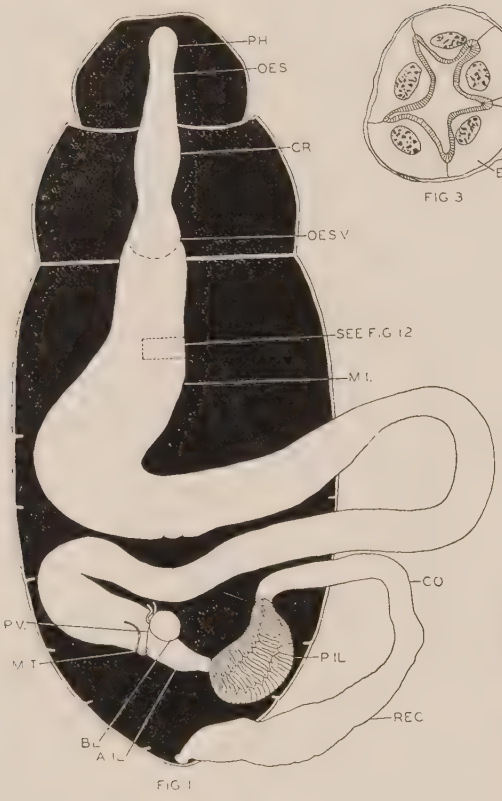


FIG 1

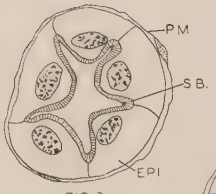
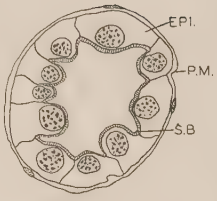


FIG 3



F.G 4.

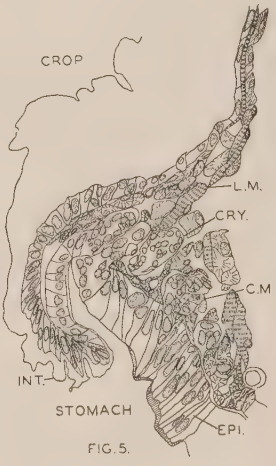


FIG. 5.

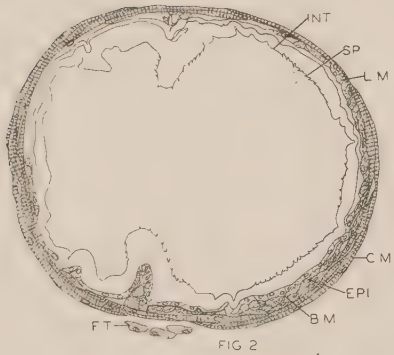


FIG 2

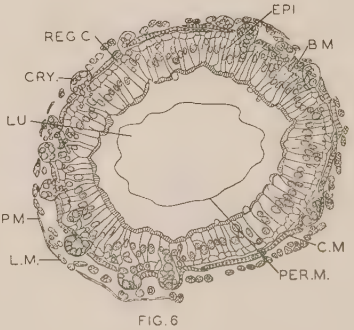


FIG. 6

FIG 7

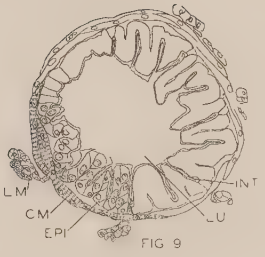


FIG 9

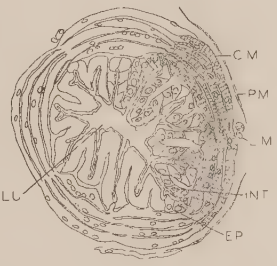


FIG 0

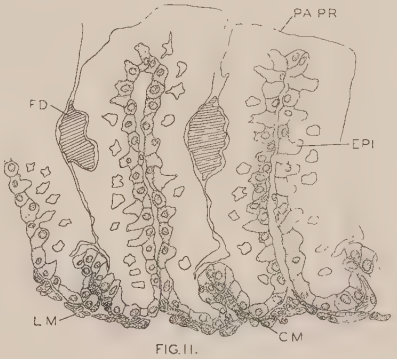


FIG. 11.

FIG. 8.

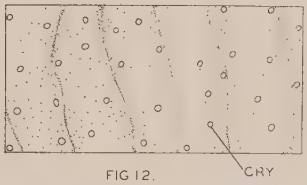


FIG 12.

BOOK NOTICES

A Revision of a Standard Text in Astronomy

Since 1927 when the second volume of "Astronomy" by Russell, Dugan and Stewart was written, this work has been the standard text and reference work on astrophysics and stellar astronomy. Since that time many new developments have occurred, particularly in astrophysics. It is interesting and rather astonishing to note that these new developments require in the main that the volume need be expanded rather than revised. This may be interpreted in either of two ways:

Either the authors have not found it expedient to revise the volume in its entirety or their original choice of material was so well made that only additions were necessary to bring the volume up to date. The reviewer has examined the book carefully and finds that a combination of the two interpretations is probably the correct one. A complete revision would have involved an amount of labor that would not have been justified by the additional gain in coherence over what has been achieved by the simple addition of new material. This must be construed as a tribute to the original judgment of the authors.

The new volume as it now stands is subject to the same criticisms that could be made of the old volume. The greatest of these concerns the pictorical material on which so much expense was saved by the printers that it is of little value in many cases. Typical of this is the poor quality of the reproductions of the many spectrograms most of which are so poor that they are of little help to the reader.—*C. E. Hesthal.*

Astronomy Vol. II, Astrophysics and Stellar Astronomy, by Russell, Dugan and Stewart. xii+488+xxx (appendix) pp. Boston, Ginn and Co. 1939.

Plane Sets of Points

This is an excellent little book in more ways than one. Topology is one of the most important fields in modern mathematics, and some of the most outstanding achievements of the mathematical research work of this century belong to the field of Topology. The book under review serves, in the first place, the important purpose of providing a picture of modern Topology in a manner that should appeal to the non-specialist. By restricting the discussion to the study of the plane, technical difficulties are almost entirely eliminated and the author can concentrate upon the methods and ideas underlying the theory. The discussion is strictly scientific, but extremely clear and careful, and should be within the reach of anybody who took some graduate work in mathematics. Still, there is very little in the book that is trivial. In fact, most of it represents the best thought of modern mathematics, both in results and in methods. The book also serves, in the second place, the equally important purpose of providing a textbook for those professional mathematicians who do not specialize in Topology, but have to use topological results and methods in their work, either in teaching or in research. The theory of functions of a complex variable is the field which the author of the book had primarily in mind in selecting his material, but the reviewer, judging by his own experience, feels that the book should be extremely valuable for all those who are engaged in research involving double integrals. The typography of the book is excellent.—*Tibor Rado.*

Elements of the Topology of Plane Sets of Points, by N. H. A. Newman. viii+221 pp. Cambridge, at the University Press; New York, the Macmillan Co. 1939. $3.50.

Parasites

The author has written a lively and whimsical account of the protozoa and of his journeys while studying them. When prose fails he turns to poetry, some of which is quite clever. The illustrations are of two kinds: some are standard drawings, diagrams, or photographs, others appear to have been done under the influence of James Thurber. Of these latter, some are excellent, others rather pointless.

Although it is difficult to predict just how much actual parasitology the average reader will learn from this book he will certainly find it both interesting and entertaining.–*J. M. Birkeland.*

Big Fleas Have Little Fleas, or, Who's Who Among the Protozoa, by Robert Hegner. 285 pp. Baltimore, The Williams & Wilkins Co. 1939. $3.00.

Social Life of Animals

This subject is ably and very interestingly discussed by one of the leading authorities in the field of animal social life and animal behavior. For some thirty years Dr. Allee has experimented in this field. After an interesting introductory discussion of the history and the development of natural history and many observations made by early workers the author traces the development of co-operation among animal types and the effects of overcrowding. From this is developed the idea of animal aggregations and the effect of mixed populations, the behavior of groups of animals and their effects upon each other especially as regards such phenomena as the rate of learning. The author discusses group organization among animals in general and draws some human implications illustrated by international attitudes and animal reactions of human beings. Finally social transitions are discussed and the author attempts to answer the question, "When does an animal become truly social?" The entire treatise is interesting reading and illustrations are drawn largely from experiments of the author, his students and co-workers.—*D. M. DeLong.*

The Social Life of Animals, by W. C. Allee. 293 pp. New York, W. W. Norton & Company Inc. 1938. $3.00.

The World of Insects

This volume is written in popular style, is practically non-technical in use of terminology, and covers the "world of insects" in an effective manner for the layman. Because of its popular nature it should be an excellent text or supplementary reading for high school biology courses.

The contents by chapters are as follows: Introduction, Insect Structures, How Insects Grow Up, the Growing Up of a Swallow-tail Butterfly, Insect Foods and Feeding Habits, Insect Food-Getting Devices, How Insects Reproduce, How Insects Get Air, How Insects Move, How Insects Are Protected, Insect Voices, Insect Fitness, Insect Orders, Social Life Among the Insects, The Value of Insects, Injurious Insects and Their Control, Where to Look for Insects, Rearing Insects, How to Collect and Preserve Insects.

One of the outstanding features of the book is the excellence of the many photographs and drawings. The striking black and white pen and ink drawings and the greatly enlarged photographs, the great majority of which are original, catch the eye of the reader readily.

A selected list of references is given at the end of the book, arranged according to the fields to which they apply.

This fascinating book is printed and bound in the usual high quality of McGraw-Hill Books.—*R. H. D.*

The World of Insects, by Carl D. Duncan and Gayle Pickwell. 409 pp. 194 Figures. New York, the McGraw Hill Book Company. 1939. $3.50.

Cosmic Rays

This small book, written in a very lucid style, is based upon the revision of three semi-popular lectures delivered at the University of Virginia and Trinity College. Lecture I treats with the discovery and general significance of cosmic rays. The early works of Kolhörster are pointed out. Millikan's answer to the question, "What are cosmic rays good for?" expresses a very worthy point of view. Lecture II treats with the superpower particles which make up the penetrating cosmic rays. Many cloud chamber pictures show the existence of positrons and particle showers. A very excellent section on the evidences for the new mesotron particle, about 150 times as heavy as the electron, is given toward the later part of this lecture. Lecture III treats with the relationship of the earth's magnetic field to the cosmic ray energies and their terrestrial distribution. The latitude effect in cosmic rays is

summarized in print and in graphs. The book closes with speculations as to the place and mode of the origin of the cosmic rays. Forty-two figures help to make this a very readable book. It is highly recommended to any one who wishes the large field of cosmic rays boiled down to a very digestible form within a reading time of a few hours.—*M. L. Pool.*

Cosmic Rays, by R. A. Millikan, 134 pp. New York, The Macmillan Co. 1939. $2.50.

Science and Society

In a period when the social importance of all our institutions is being challenged, it is not surprising to find that science has been minutely examined. This volume is an analysis of what science does for the people of the world and a prediction of what it could do if reorganized according to one author's plans. The historical aspects are authoritatively dealt with. Science has always been an outgrowth of necessity: it is not a luxury. Pure science, which is what the layman so often thinks of, originated in the early part of the 19th century. Although science has developed because of the practical aspects, its financing has been extremely indefinite.

Scientific organizations from the first one, Accademia de Lincei, founded in Rome (1601) to the American Association of Scientific Workers are considered in detail. The scientist and particularly his welfare, and attempts to better highly unsatisfactory conditions in employment through organization, are thoroughly discussed. One sees the contributions, past and present, of different nations contrasted and the development and utilization of science in these nations influenced by political ideologies.

The faults of industrial, governmental, and scholastic institutions, all of which support and direct research, are abundantly presented and a plan of reorganization is offered. This section has been read with very great care and this reviewer is bewildered over the fact that the features in administration, so severely condemned in old systems, remain in the scheme of reorganization. Although the section on administrative difficulties appears abortive, there are many splendid contributions on other topics. Some major problems considered are future expansion, the training of scientists which involves reorganization of existing curricula, employment at adequate salaries, the future nature of the different sciences, scientific communication, and the finance of science. Communication, for instance, is essential and involves travel, numerous languages, over 33,000 periodicals, and thousands of monographs each year. This phase of the scientists' life lacks organization at present.

This book contains sections that are debatable and much bias of opinion is evident. A tremendous amount of data is offered and the social involvements are admirably presented. The author has written for the inquiring minds of all scientists, and people in other fields of activity interested in science. The content of this book demand attention as the issues involved are real ones.—*Carl E. Venard.*

The Social Function of Science, by J. D. Bernal. 482 pp. New York, the Macmillan Co. 1939. $3.50.

Physiological and Pathological Chemistry

In preparing a text book of chemistry for nurses, the author has kept in mind the fact that while some schools of nursing offer a so-called long course in chemistry consisting of ninety clock hours, there are many other schools in which only thirty to forty hours are allotted to the teaching of chemistry. He has therefore attempted to eliminate all unimportant and unessential details in order to make the material actually presented as clearly as possible to the student nurse. However, the graduate nurse who frequently has to serve as instructor in chemistry as well as in other subjects will also find the book useful, as well arranged lists of study questions have been included at the end of each chapter.

The book is divided in three parts. Part I, designated as an introduction to chemical science, discusses selected topics in a clear and readable style which the student nurse ought to be able to follow without too much difficulty. Weighing and measuring, chemical substances, elements, compounds, atoms, molecules, symbols, formulas, chemical equation, valence, oxygen, energy transformations, water, types of solutions, and some of their properties, emulsions, osmosis, colloidal

systems, acids, bases, salts, ionization, pH notation, buffers, oxidation-reduction reactions and finally a chapter of introductory organic chemistry are among the subjects included in Part I. pH notation is the only topic presented in such a way that additional aid beyond the text book is required. Since the author has presented most of his material in such a clear fashion, it seems regrettable that a few pages devoted to the chemistry of hydrogen, the halogens, nitrogen and ammonia, and carbon and carbon dioxide could not have been included.

Part II, entitled Physiological and Pathological Chemistry, deals with the nature of enzymes, the chemistry and metabolism of lipids, carbohydrates, proteins, digestion, inorganic metabolism, the urine, hormones, vitamins and an introduction to nutrition and dietetics, including the types of diets prescribed in certain illnesses. The order or presentation of some of the topics is the only reason for unfavorable criticism of this section of the book. Since food must be digested and absorbed before the reactions described in the chapters devoted to metabolism can take place, it would seem a more logical arrangement to discuss digestion and absorption before metabolism. Furthermore, since the author has recommended the use of only part of his text book for short courses in chemistry for nurses, the reviewer believes that a student nurse could make more practical use of her information if she were to study digestion and absorption than if she had a hazy idea about intermediate metabolism. (Digestion follows immediately after the chapters recommended for a short course).

Part III consists of a series of laboratory exercises covering the material discussed in Parts I and II, while the appendix contains useful directions for removing stains from clothing and bedding.

Although there are numerous points throughout the text to which one may take exception, the reviewer feels that the book makes a distinct contribution to the teaching of nurses and is a decided advance over other chemistry texts written especially for nurses.—*Helen L. Wikoff*

An Introduction to Physiological and Pathological Chemistry, by L. Earle Arnow, 555 pp., St. Louis, The Mosby Co. 1939. $3.50.

Ecology and Society

The author of "Deserts on the March" and "This is Our World" has prepared in this remarkable little book a concise yet broad overview of the interrelations of living things. The work of the botanist, zoologist and ecologist is often specialized, and its broader implications are seldom recognized by society; often, in fact, are not recognized by the workers themselves. Now and then a biologist not only glimpses the vast horizons of ecology, but is capable of translating the deeper and all-pervading theme into the practical language of commerce, business, health, and community existence. Such a man is Paul Sears, and we tender him deserved praise for setting forth so clearly the social functions of ecology.—*L. H. S.*

Life and Environment, by Paul B. Sears. xi + 175 pp. New York, Bureau of Teachers College, Columbia University. 1939. $1.85.

All About the Blood Groups

Wiener's revised edition should prove to be a most valuable source book for those workers in the various fields in which the blood groups play major roles.

Certain out-of-date items and superfluous explanations have been deleted while all the very latest principles and technics pertaining to the use of the blood groups have been added. Practically every chapter has undergone revision and this revision has been done in terms of deleted or added materials; that is, rewritten in such a way that the reader is not bothered by a "patch-quilt" sort of affair.

Dr. Wiener thoroughly discusses the sub-groups of A and AB as to sensitivity, reactivity, heredity and distribution. The chapters on the M and N groups are enlarged and brought up-to-date while the chemistry of all the substances is discussed more fully than in the previous edition. The anthropology of the varied groups is given in more detail and includes the most recent facts pertaining to their distribution.

The chapter on selection of donors and survival of transfused blood cells has been enlarged to include a chart of correct procedure for cross-matching bloods, a discussion of "blood banks," physical examination of blood donors, and professional

and volunteer donors. The best and latest technics for transfusing blood are given and space is devoted to discussing the advantages and disadvantages of transfusing preserved blood.

Two chapters have been made out of the original one on indications for and reactions to blood transfusions. The first deals with indications for and results of transfusions; the second with reactions to transfusions. The chapter on the medico-legal applications of the groups has also been made into two. One deals with the applications of the groups in cases of disputed paternity, the other with individual identifications of stains.

These are but a few of the many changes which help to round out an altogether satisfactory and necessary book.—*H. S. Hyman.*

Blood Groups and Blood Transfusion, by Alexander S. Wiener. Second edition., 306 pp., Springfield, Charles C. Thomas. 1939. $5.00.

Principles of Forest Entomology

Following the same style of presentation as used in the first edition, Professor Graham has enlarged and rewritten many parts of his well known text in forest entomology in the recently published second edition.

Some of the additions include discussions of pests not mentioned in the previous edition, namely, the Pandora moth, European Spruce Sawfly, European Pine Shoot Moth, Melanophila beetles, and a number of other Lepidopterous leaf-eaters. The sections dealing with barkbeetles and termites have also been greatly enlarged. A new chapter dealing with other relations of forest insects appears at the end of the book. It includes discussions of insects as transporters of insects; the relation of insects to wood rot and stains, parasitic fungi, and virus diseases; followed by a glimpse into the future. The questions on literature are omitted in the revision.

The chapters on biotic balance, environmental resistance, biotic potential and insect abundance have been expanded to include information from investigations of the past ten years. They cover the underlying principles which should be considered for the control of any insect problem, but are so very important to the forest entomologist or forester because of the inapplicability of most chemical control measures to forested areas.

A few more illustrations have been added, the first edition having 149 and the second 165.

In the revised form the book should continue to serve as a standard text on the subject for years to come.—*R. H. Davidson.*

Principles of Forest Entomology, by S. A. Graham. Second edition, 410 pp. New York, the McGraw-Hill Book Co. 1939. $4.00.

Racial Origins

At a time when the scientific knowledge of human racial types, especially in Europe, is bandied about and perverted for various extraneous ends it is fitting that a book of this scope and dispassionate impartiality should be published. Coon has provided us with a highly condensed, efficiently organized compendium of the extant knowledge concerning the physical form of man in Europe and the adjacent portions of Asia and Africa from the time of *Homo sapiens'* first appearance in the late Pleistocene to the year 1938. The complex story of the origin, evolution, mixture and migration of European physical types has been correlated wherever possible with culture, linguistics, political divisions of the various periods and of course with geography and chronology. Over 4000 sources in at least 21 different languages have been abstracted for the anthropometric data alone. The basic thesis of the book is that the living white types of Europe owe their original differentiation to a dual origin, namely, (1) a *Neaderthaloid-sapiens* hybrid type which the author believes inhabited Europe during the later part of the Ice Age, and (2) a purely *sapiens* Mediterranean stock with several varieties which began colonizing Europe from the south and east about 3000 B. C. Ten racial types and nine subtypes are recognized in the present white population of Europe. The reader who is familiar with the earlier work of the same name published about 40 years ago by W. Z. Ripley, to whom the present work is dedicated, will find the former work superceded in almost all respects, so great has been the accumulation of anthropological data in

the interval. The physical anthropologist, however, is still forced to deal almost exclusively with phenotypes and Coon's conclusions regarding origins, while for the most part eminently sound in the light of present knowledge, must await more extensive data on human genetics before they will be finally vindicated or rejected. —*John Gillin.*

The Races of Europe, by Carleton S. Coon. xvi+739 pp. New York, the Macmillan Co. 1939. $7.00.

The Romance of Silver Mining

Of particular interest in these days of governmental expropriation is this account of the fortunes of the Shepherd family in the Chihuahua silver mines. Mistakenly given to me for review as a physicist because of its title, "The Silver Magnet," I nevertheless spent several interesting hours with this book. In 1880, the Shepherd family (nine of them!) and a group of specialists and servants, seventeen in all, left the comforts of Washington where the senior Shepherd (the father of the author) was a Governor of the District of Columbia (a new office to this reviewer) and started on the long and tedious journey to Batopilas, Chihuahua. Here they took over a mine in a two hundred fifty year old mining locality and tried to run it with American efficiency. Details of the process of getting the silver to railhead six hundred miles away, and of the government of Mexico before and during the time of Porfirio Diaz take up several chapters. An account follows of the education of the author back in the United States and of his adventure on the way back to Batopilas. Then work, which seems to be glossed over lightly, while vacation journeyings all over Mexico occupy a great deal of space. The history ends with a defense of Diaz and a diatribe against the "great liberator," Villa.—*J. B. Green.*

The Silver Magnet, by Grant Shepherd, 302 pp. New York, E. P. Dutton and Co. 1939. $3.00.

Conservation

This volume by four members of the Cornell faculty aims to present for the average citizen the basic facts and principles governing the use of our natural resources. The authors are authorities in the areas covered, and the presentation is ably accomplished with readable text and excellent illustrations. The broad viewpoint of national welfare requires breadth of view of the fields treated, but more emphasis could have been placed upon wise use, and avoidance of waste, and less upon simply conserving. The authors' thesis is that the ruthless exploitation of our natural resources can be stopped only by intensive and extensive co-operation between the Federal and State governments, great and little corporations, and individual citizens. More emphasis should have been placed upon methods of effecting such co-operation, and less upon centralizing responsibility and authority in Federal and international agencies.

The expressed aim of this book is to foster conservation consciousness in the individual citizen by giving him an understanding of the problems. This book makes plain the complexity of the job, and the average citizen who reads it will probably decide that the job can only be handled by people who make it their vocation. All books of the kind will doubtless help the cause of conservation, but nothing short of a vigorous emotional appeal, presented to a bigger audience could hope to incite the co-operative action called for, and then only if accompanied by directions for specific actions by every individual.—*T. H. Langlois.*

Conservation in the United States, by A. F. Gustafson, H. Reis, C. H. Guise, and W. J. Hamilton, Jr. xi + 445 pp. Ithaca, Comstock Publishing Co. 1939. $3.00.

Bibliography of Drosophila Genetics

Drosophila stands at the pinnacle of experimental material for the study of genetics. The fourteen years from 1910 to 1924 resulted in 381 titles, listed in "The Genetics of Drosophila." The fourteen years from 1925 to 1938 provided seven times as many articles, namely, 2,584, making a total of 2,965 titles listed in the excellent bibliography now under review. The arrangement is alphabetical by authors, no attempt being made to classify the subjects. The bibliography is

practically complete on the genetic side, and reasonably so in matters of morphology, physiology and systematics. It should be invaluable to geneticists; and the Imperial Bureau of Animal Breeding and Genetics is to be commended for undertaking its publication.—*L. H. S.*

Bibliography on the Genetics of Drosophila, by H. J. Muller, 132 pp., paper bound. Edinburgh, Oliver and Boyd. 5s.

North American Snakes

Dr. Raymond L. Ditmars, already the author of a number of noteworthy books on reptiles, again brings together in this volume herpetological material otherwise available only in widely scattered technical papers, and presents it in non-technical terms useful to both the specialist and layman. Beginning with a general discussion of the distribution, ecology and behavior of various types of snakes of the North American continent, he deals with the snakes of northeastern, southeastern and western North America in three separate parts of the text. For each area, each recognized species and sub-species is listed in a simplified key and subsequently described in considerable detail with regard to size, form and scalation, color, distribution, and habits. Poisonous species of each region are discussed separately from the non-poisonous species. Part V includes a useful chapter on the treatment of snake bites in both man and domestic animals, together with an excellent discussion of the preparation and action both of venom and of anti-venom serum. This is followed by a complete classified list of North American Snakes, comprising 6 families, 48 genera, 140 species, and 138 subspecies, a list of general references, and index, and a series of 48 excellent photographic plates, designed to show diagnostic features.

To the reader already familiar with the snakes of his own locality, the over-all view of the snakes of the entire continent north of Mexico provided in this book should prove an attractive feature. The Ohio naturalist traveling outside the state should find this a useful adjunct to his field equipment.—*John W. Price.*

A Field Book of North American Snakes, by R. L. Ditmars. xii+305 pp., 48 plates. New York, Doubleday, Doran & Co., Inc. 1939. $3.50.

Saving Our Soils

Soil Conservation is a semi-technical, semi-popular discussion of soil erosion, by the Chief of the Soil Conservation Service, with the aid of various individuals within his organization. Essentially, it is an encyclopedia of the activities of the Soil Conservation Service. The book contains 993 pages, including 358 excellent photographs, 61 graphs, 17 maps and 47 tables of data.

The author develops a vivid concept of the seriousness of erosion and the reader is never left in doubt as to the author's opinions regarding the menace of erosion to agricultural soils. He cleverly presents a survey of the erosion problem of the United States upon a regional basis. He calls attention to the various factors that are responsible for soil erosion. Finally, he suggests methods for controlling erosion and explains the results that the Soil Conservation Service has achieved in the different agricultural areas of the nation.

The author leaves the impression that soil erosion is the only factor that is responsible for soil deterioration. Therefore, the book is definitely concerned with soil erosion and does not stress the broader aspects of soil conservation. It is also implied that the conservation of soils is primarily a federal responsibility in co-operation with the individual farmer and does not emphasize the contributions that the various state experiment stations have made and will continue to make to the problem of soil conservation.

This book should be in the library of every individual who is interested in any phase of conservation. It contains a wealth of material that cannot be obtained from any other source. Teachers of science should have access to the book for reference to their students, since many of the chapters fit into the subject matter of most general science courses. Soils men and agronomists will find it to be a handy encyclopedia of the various aspects of soil erosion in this country.—*L. D. Baver.*

Soil Conservation, by H. H. Bennett. 993 pp. New York, the McGraw-Hill Book Co. 1939. $6.00.

THE OHIO ACADEMY OF SCIENCE

MEMBERSHIP LIST, 1940

(F '—) Fellow, Ohio Academy of Science, with date of election.

ADAMS, C. S. (F '36)—*Chemistry*.....Antioch College, Yellow Springs
ALBRIGHT, JOHN G.—*Physics*.....Case School of Applied Science, Cleveland
ALDRICH, JOHN W.—*Biology*, esp. *Ornithology*.....2717 Euclid Ave., Cleveland
ALEXANDER, W. H. (F '20)—*Meteorology*.....Hotel Normandie, Columbus
ALEXOPOULOS, C. J.—*Botany*.....Kent State University, Kent
AMSTUTZ, MARY E.—*Zoology, Entomology*.....410 Pleasant St., Ashland
ANDERSON, AMOS C. (F '39)—*Psychology*.....30 Columbia Ave., Athens
ANDERSON, BERTIL G.—*Zoology*.....Western Reserve University, Cleveland
ARENSON, S. B.—*Chemistry*.....University of Cincinnati, Cincinnati
ASHCRAFT, D. W.—*Anatomy, Physiology*.....O. S. U., Columbus
ATWOOD, HARRY—*Botany*.....Box 746, Federal Bldg., Columbus
AUTEN, MARY (F '35)—*Zoology*.....Ashland College, Ashland
AVERY, WILLIS F.—*Physics*.....B. F. Goodrich Company, Akron

BACON, FRANKLIN J.—*Botany*.....Western Reserve University, Cleveland
BAKER, R. C. (F '39)—*Medical Sciences*.....O. S. U., Columbus
BALDUF, WALTER V.—*Zoology*.....University of Illinois, Urbana, Ill.
BANGHAM, RALPH V. (F '24)—*Zoology, Anatomy*.....1004 N. Bever St., Wooster
BARBOUR, GEORGE B.—*Geology*.....University of Cincinnati, Cincinnati
BARKER, C. A.—*Psychology*.....1017 Cumberland Ave., Dayton
BARNES, HUGHES—*Biology*.....202 N. Uhrich St., Uhrichsville
BARR, DANIEL R.—*Medicine*.....Box 137, Grand Rapids
BARROWS, WILLIAM M. (F '20)—*Zoology*.....O. S. U., Columbus
BARTLEY, FLOYD—*Botany*.....R. R. 4, Circleville
BATTELLE MEMORIAL INSTITUTE—*Metallurgy*.....505 King Ave., Columbus
BAUER, ALLEN H.—*Botany*.....Pennsylvania State College, State College, Pa.
BAUMAN, HARRY—*Entomology*.....1091 Jefferson Ave., Akron
BAYFIELD, E. G.—*Chemistry*.....Ohio Agricultural Experiment Station, Wooster
BEARDSLEE, HENRY C. (F '25)—*Botany*.....Perry
BEAVER, WILLIAM C. (F '30)—*Zoology, Medical Sciences*,
Wittenberg College, Springfield
BEHRE, CHARLES H. (F '28)—*Geology*.....Northwestern University, Evanston, Ill.
BERGER, BENJAMIN—*Medicine*.....133 W. Ninth Ave., Columbus
BERGER, F. L.—*Physics*.....121 Lehr Ave., Ada
BERNHAGEN, RALPH J.—*Geology*.....O. S. U., Columbus
BERRY, WILLARD (F '31)—*Geology*.....Duke University, Durham, N. Car.
BEVAN, ARTHUR (F '20)—*Geology*,
Box 1428, University Station, Charlottesville, Va.
BILLS, ARTHUR G.—*Psychology*.....3423 Whitfield Ave., Cincinnati
BLACKBURN, N. D.—*Entomology*...Ohio Agricultural Experiment Station, Wooster
BLAKE, F. C. (F '20)—*Physics*.....O. S. U., Columbus
BLAYDES, GLENN W. (F '35)—*Botany*.....O. S. U., Columbus
BODENBERG, EMMETT T. (F '37)—*Botany*.....Wittenberg College, Springfield
BOESEL, M. W.—*Entomology, Zoology*.....Miami University, Oxford
BOETTICHER, A. W.—*Biology*.....Ohio University, Athens
BOLE, B. P., JR.—*Ornithology*.....2717 Euclid Ave., Cleveland
BOND, CLYDE H.—*Geography, Geology*.....R. F. D. 3, Quaker City
BOORD, CECIL E. (F '39)—*Chemistry*.....O. S. U., Columbus
BORROR, DONALD J. (F '36)—*Entomology*.....O. S. U., Columbus
BOSSERT, ROY B.—*Chemistry, Bacteriology*...Ohio Wesleyan University, Delaware

Bosworth, Alfred W.—*Biological Chemistry*.....R. R. 4, Circleville
Bowman, H. H. M. (F '21)—*Botany, Zoology*.....University of Toledo, Toledo
Boyd, Milford J.—*Biological Chemistry*.....2347 Fairview Ave., Cincinnati
Brand, Louis (F '39)—*Mathematics*.....2603 University Ct., Cincinnati
Brand, P. J.—*Geography*.....341 W. Main St., Newcomerstown
Brant, A. M.—*Mineralogy, Geology*.....O. S. U., Columbus
Braun, Annette F. (F '22)—*Zoology*.....2702 May St., Cincinnati
Braun, E. Lucy (F '21)—*Botany*.....2702 May St., Cincinnati
Braund, Frank W.—*Natural History*.....1022 Carnegie Ave., Cleveland
Bridgham, Mrs. Catherine M.—*Botany*.....R. F. D. 1, North Jackson
Brief, B. J.—*Medicine*.....769 Kimball Place, Columbus
Brill, H. C.—*Chemistry*.....Miami University, Oxford
Bromley, Mrs. Helen J. Brown (F '31)—*Botany*,
High Ridge Road, Stamford, Conn.
Brooks, Arthur S.—*Botany, Zoology*.....413 South Ave., Van Wert
Brower, A. B.—*Medical Sciences*.....60 Wyoming St., Dayton
Brown, J. B. (F '39)—*Medicine*.....O. S. U., Columbus
Bryant, E. R.—*Biology*.....117 Lakeside, New Concord
Bucher, W. H. (F '20)—*Geology, Physics*.....University of Cincinnati, Cincinnati
Budington, R. A. (F '20)—*Zoology, Physiology*.....Oberlin College, Oberlin
Bulger, J. W.—*Entomology, Plant Pathology*,
Beltsville Research Center, Beltsville, Md.
Bunch, Rosella—*Geology*.....186 W. College St., Oberlin
Burgess, Wayland M.—*Chemistry*.....University of Cincinnati, Cincinnati
Burrell, R. C.—*Agricultural Chemistry*.....O. S. U., Columbus
Burtt, Harold E. (F '21)—*Psychology*.....O. S. U., Columbus
Busch, Daniel A.—*Geology, Chemistry*..University of Pittsburgh, Pittsburgh, Pa.
Busch, Harvey L.—*Zoology*.....1596 Parkwood Road, Lakewood
Busch, K. G. A. (F '36)—*Chemistry*.....Capital University, Columbus
Busch, Karl H.—*Zoology*.....O. S. U., Columbus

Carlson, Fred A. (F '38)—*Geography*.....O. S. U., Columbus
Carman, J. Ernest (F '20)—*Geology*.....O. S. U., Columbus
Cecil, Rodney—*Entomology*.....Box 1330, Ventura, Calif.
Chandler, David C.—*Biology, Limnology*.....Stone Laboratory, Put-in-Bay
Chapman, Floyd B.—*Botany*.....1944 Denune Ave., Columbus
Chase, Samuel W. (F '24)—*Zoology*.....2109 Adelbert Road, Cleveland
Childers, Norman—*Horticulture*.....O. S. U., Columbus
Chittam, John W.—*Chemistry*.....College of Wooster, Wooster
Church, Margaret B.—*Botany*.....Lyndon, Vt.
Clark, Paul E.—*Chemistry*.....New Concord
Cleveland Museum of Natural History—*Botany, Zoology*,
2717 Euclid Ave., Cleveland
Clippinger, Florence—*Botany*.....4300 Midway Ave., Dayton
Coghill, G. E.—*Neurology, Zoology*.....R. F. D. 2, Box 77-A, Gainesville, Fla.
Cole, Lawrence E.—*Psychology*.....111 S. Cedar St., Oberlin
Cole, W. S. (F '36)—*Geology*.....O. S. U., Columbus
Coles, Victor—*Ornithology, Botany*.....2910 Grasselli Ave., Cincinnati
Conrey, G. W. (F '24)—*Geology*.....O. S. U., Columbus
Consolata, Sister Mary—*Chemistry*.....2234 Overlook Road, Cleveland
Cooper, John R.—*Geology*.....Ohio Wesleyan University, Delaware
Costello, Robert E.—*Biology*.....914 Perry St., Defiance
Cotterman, Charles W.—*Genetics*.....O. S. U., Columbus
Cottingham, Kenneth C. (F '29)—*Geology*.....384 Seventeenth Ave., Columbus
Coyle, Elizabeth E.—*Botany*.....College of Wooster, Wooster
Crist, E. L.—*Botany*.....I. O. O. F. Bldg., Circleville
Crowl, Gordon S.—*Botany*.....O. S. U., Columbus
Cunningham, Harry A.—*Biology*.....227 N. Depeyster St., Kent
Cunningham, John F.—*Zoology, Entomology*.....O. S. U., Columbus
Curtis, George M. (F '39)—*Medical and Biological Sciences*...O. S. U., Columbus
Cutright, Clifford R. (F '30)—*Zoology, Entomology*,
Ohio Agricultural Experiment Station, Wooster

DAKAN, E. L.—*Zoology*.....O. S. U., Columbus
DAMBACH, CHARLES A.—*Ecology, Entomology*.....1902 Auburn Ave., Dayton
DARLING, FRED S.—*Physical Sciences*,
Box 279, Ste. Anne-de-Bellevue, Province of Quebec, Canada
DAVIDSON, RALPH H. (F '36)—*Entomology*.....O. S. U., Columbus
DAVIS, B. M.—*Physiology*, esp. *Zoology*.....Oxford
DEAM, CHARLES C. (F '30)—*Botany, Forestry*.....Bluffton, Ind.
DEAROLF, KENNETH.....Dayton Public Library and Museum, Dayton
DELONG, D. M. (F '21)—*Entomology*.....O. S. U., Columbus
DE MARINIS, FRANK—*Zoology*.....2170 Stillman Road, Cleveland Heights
DEVEREAUX, WM. C. (F '22)—*Meteorology*.....U. S. Weather Bureau, Cincinnati
DEXTER, RALPH W.—*Biology, Ecology*.....Kent State University, Kent
DICKERMAN, E. EUGENE—*Zoology*,
Bowling Green State University, Bowling Green
DIETZ, DAVID (F '33)—*Astronomy, Physics*...2891 Winthrop Road, Shaker Heights
DIETZ, HARRY F. (F '32)—*Entomology*.....2805 Monroe St., Wilmington, Del.
DILLER, OLIVER D.—*Botany*.....Ohio Agricultural Experiment Station, Wooster
DOAN, CHARLES A. (F '39)—*Medical and Biological Sciences*....O. S. U., Columbus
DOAN, KENNETH H.—*Zoology, Ecology*.....Stone Laboratory, Put-in-Bay
DOBBINS, RAYMOND A. (F '38)—*Botany*.....Ohio Northern University, Ada
DOCKERAY, F. C. (F '24)—*Psychology*.....O. S. U., Columbus
DODD, D. R.—*Botany, Geology*.....O. S. U., Columbus
DRAKE, CARL J. (F '21)—*Entomology*.....Iowa State College, Ames, Iowa
DUNGAN, THEODORE C.—*Psychology, Physics*.....83 Sixteenth Ave., Columbus
DUNLAP, H. L.—*Chemistry*.....275 E. State St., Athens
DURRANT, E. P. (F '20)—*Zoology, Geology*.....O. S. U., Columbus

EBAUGH, W. C.—*Chemistry*.....Denison University, Granville
EDWARDS, E. H.—*Zoology, Physiology*.....1548 Rockway Ave., Lakewood
EDWARDS, L. F. (F '32)—*Medicine*.....O. S. U., Columbus
EDWARDS, R. L. (F '32)—*Physics*.....Miami University, Oxford
EGGLESTON, H. R.—*Biology*.....Marietta College, Marietta
EHLERS, G. M.—*Geology*.....University of Michigan, Ann Arbor, Mich.
ELLIOTT, RUSH (F '33)—*Zoology, Medicine*.....Ohio University, Athens
ELSASS, DONALD H.—*Zoology*.....Capital University, Columbus
ENGLE, O. H.—*Zoology, Botany*.....1409 Robinwood Road, Alliance
ENGLISH, HORACE B. (F '30)—*Psychology*.....O. S. U., Columbus
ERF, HERBERT A.—*Physics*.....16827 Fernway Road, Shaker Heights
EVANS, ARTHUR T. (F '31)—*Botany*.....400 E. Chestnut St., Oxford
EVANS, MORGAN W.—*Agronomy, Botany*,
Ohio Agricultural Experiment Station, Wooster
EVANS, WILLIAM L. (F '21)—*Chemistry*.....O. S. U., Columbus
EVERHART, W. A.—*Chemistry*.....Denison University, Granville
EVERLY, RAY T.—*Entomology*.....Holmesville
EY, L. F.—*Bacteriology*.....O. S. U., Columbus

FARIES, RUTH—*Medical Zoology, Botany*,
Bellevue Nurses' Home, 426 E. 26th St., New York, N. Y.
FATTIG, P. W.—*Zoology*.....Box 788, Emory University, Ga.
FEDERIGHI, HENRY—*Biology*.....Antioch College, Yellow Springs
FENNEMAN, N. M. (F '20)—*Geology, Geography*,
University of Cincinnati, Cincinnati
FERNELIUS, W. C. (F '36)—*Chemistry*.....O. S. U., Columbus
FIDDLER, MRS. CLARICE—*Botany*.....Hotel Hester, Manchester
FIELDS, PAUL E.—*Psychology*.....138 N. Sandusky St., Delaware
FISCHER, MARTIN H. (F '20)—*Experimental Medicine*,
College of Medicine, Cincinnati
FORD, EARL W.—*Physics*.....Station 2, Wooster
FOREMAN, FRED (F '35)—*Geology*.....217 Woodland Ave., Oberlin
FRANKS, ROSCOE W.—*Ornithology, Botany*.....State Office Bldg., Columbus
FREEMAN, B. C. (F '39)—*Geology*.....O. S. U., Columbus

FRIESNER, RAY C. (F '34)—*Botany*.....Butler University, Indianapolis, Ind.
FROMM, GUY—*Physics*.....Capital University, Columbus
FRONIUS, ARTHUR G.—*Chemistry*.....785 New Garden Ave., Salem
FROST, REUEL B. (F '35)—*Geology*.....21 N. Cedar St., Oberlin
FRYE, WALTER—*Geology*.....Central High School, Akron
FULFORD, MARGARET (F '36)—*Botany, Geology*, University of Cincinnati, Cincinnati
FULLMER, E. L. (F '20)—*Biology*.....Baldwin-Wallace College, Berea
FUNK, JOHN L.—*Zoology*.....808 W. Spruce Ave., Ravenna

GARRETT, ALFRED B.—*Chemistry*.....O. S. U., Columbus
GEBHART, JAMES W.—*Zoology*.....4926 Donald Ave., South Euclid
GEIST, ROBERT M. (F '32)—*Entomology*.....Capital University, Columbus
GIBBONS, CHARLES C.—*Psychology*.....71 W. Frambes Ave., Columbus
GIER, HERSCHEL—*Ornithology*.....Ohio University, Athens
GILLESPIE, J. S.—*Geology*.....1075 Madison Ave., Columbus
GILLIN, GERTRUDE M.—*Zoology, Botany*,
2175 Middlefield Road, Cleveland Heights
GLENNY, FRED H.—*Botany*.....1148 Linden Ave., Akron
GOLDBERG, LAWRENCE—*Medical Sciences*.....38 W. Washington, Athens
GOSLIN, CHARLES R.—*Botany*.....407 Washington Ave., Lancaster
GOSLIN, ROBERT M.—*Zoology*.....316 Wilson Ave., Columbus
GOURLEY, J. H. (F '26)—*Horticulture*.....O. S. U., Columbus
GOWDY, ROBERT C. (F '20)—*Physics*.....2111 Auburn Ave., Cincinnati
GRADY, ROY I.—*Chemistry*.....College of Wooster, Wooster
GRAY, J. C.—*Biology*.....Western Reserve University, Cleveland
GRIMM, WILBUR W.—*Zoology*.....Lincoln Memorial University, Harrogate, Tenn.
GROVE, BERT E.—*Geology, Biology*, Field Museum of Natural History, Chicago, Ill.
GROVER, F. O. (F '20)—*Botany*.....270 Elm St., Oberlin

HAHNERT, WM. F.—*Zoology*.....Ohio Wesleyan University, Delaware
HALE, KELLEY—*Medical Sciences*.....626 W. Main St., Wilmington
HAMILTON, FRANK E.—*Medical Sciences*.....O. S. U., Columbus
HAMILTON, M. J.—*Geology, Zoology*.....1753 Kensington Ave., Youngstown
HANSEN, MRS. HERMINA Z.—*Biology*.....41 N. Portage Path, Akron
HARPER, A. R.—*Botany, Zoology*.....559 Arden Road, Columbus
HARTMAN, FRANK A.—*Medical Sciences*.....O. S. U., Columbus
HARTSON, L. D. (F '32)—*Psychology*.....Oberlin College, Oberlin
HAUB, JAMES G.—*Zoology*.....O. S. U., Columbus
HAVEN, S. EDSON—*Psychology*.....Wayne University, Detroit, Mich.
HAYHURST, EMERY R. (F '21)—*Medical Sciences*....1925 Concord Road, Columbus
HAZARD, FRANK O.—*Biology*.....Wilmington College, Wilmington
HEFNER, ROBERT A. (F '32)—*Zoology*.....Miami University, Oxford
HEIZER, EDWIN E.—*Zoology*.....University of Wisconsin, Madison, Wis.
HENDERSON, WILLIAM E. (F '21)—*Chemistry*.....O. S. U., Columbus
HENDRICKSON, GORDON—*Psychology*.....University of Cincinnati, Cincinnati
HERBERT, GALE A.—*Biology*.....Box 2682, Whitehouse
HERRICK, ERVIN M.—*Botany*.....R. R. 1, Hudson
HERRICK, FRANCIS H. (F '20)—*Zoology*.....Adelbert College, Cleveland
HERRICK, J. ARTHUR—*Biology*, esp. *Plant Pathology*..Kent State University, Kent
HERSH, A. H. (F '35)—*Zoology*.....Western Reserve University, Cleveland
HESKETT, CLARENCE—*Geography*.....O. S. U., Columbus
HESS, EMILY R.—*Biology, Chemistry*.....141 Mays Ave., Ft. Thomas, Ky.
HIBBARD, HOPE (F '31)—*Zoology*.....Oberlin College, Oberlin
HICKS, LAWRENCE E. (F '34)—*Botany*.....O. S. U., Columbus
HILLS, MYRA E.—*Psychology*.....2836 Scarborough Road, Cleveland Heights
HILLS, T. M. (F '20)—*Geology*.....Vassar College, Poughkeepsie, N. Y.
HITCHCOCK, FRED A. (F '28)—*Zoology, Physiology*.....O. S. U., Columbus
HODGMAN, CHARLES D.—*Physics*.....Case School of Applied Science, Cleveland
HODGMAN, MARGARET E.—*Botany*.....2119 Marlindale Road, Cleveland Heights
HOKE, ROY DAVIS—*Geology, Physics*.....1750 S. Union Ave., Alliance
HOLLINGSWORTH, MARION—*Chemistry*.....O. S. U., Columbus

HOOD, G. R.—*Chemistry*.....711 Oak St., Oxford
HOPKINS, EVERETT H.—*Psychology*.....North Hampton
HOSKINS, J. HOBART (F '27)—*Botany*.....University of Cincinnati, Cincinnati
HOUSEHOLDER, FRED F.—*Physics*.....1209 Berwin St., Akron
HOUSER, J. S. (F '21)—*Entomology*, Ohio Agricultural Experiment Station, Wooster
HOUSLEY, C. R.—*Zoology, Botany*.....Elmore
HOWARD, NEALE F. (F '32)—*Entomology*.....151 W. Eleventh Ave., Columbus
HOWLETT, F. S.—*Agriculture*.....Ohio Agricultural Experiment Station, Wooster
HUBBARD, GEORGE D. (F '20)—*Geology*.....125 Woodland Ave., Oberlin
HUBER, H. E.—*Biology*.....Ohio Northern University, Ada
HUDSON, N. PAUL (F '39)—*Medicine*.....O. S. U., Columbus
HUGHES, JOHN H.—*Biology*.....81 W. South St., Jackson
HULL, H. BLAIR—*Engineering*.....P. O. Box 671, Dayton
HUMPHREY, S. S.—*Botany*.....O. S. U., Columbus
HUNTINGTON, C. C. (F '37)—*Geography*.....O. S. U., Columbus

INMAN, O. L. (F '26)—*Physiology*.....Antioch College, Yellow Springs
IRELAND, H. A.—*Geology*.....447 N. Broadway St., New Philadelphia
IRWIN, N. MILDRED—*Botany*.....5017 Anderson Place, Cincinnati

JACOBS, EDWIN E. (F '36)—*Botany, Geology*.....Ashland College, Ashland
JARVIS, C. W.—*Physics*.....Ohio Wesleyan University, Delaware
JENNINGS, OTTO E. (F '20)—*Botany*.....Carnegie Museum, Pittsburgh, Pa.
JOHNSON, E. H. (F '28)—*Physics*.....Box 65, Gambier
JOHNSON, HOWARD W.—*Botany*.....Arlington Experiment Farm, Arlington, Va.
JONES, CLYDE H.—*Botany*.....O. S. U., Columbus
JONES, DAVID T.—*Zoology*.....University of Utah, Salt Lake City, Utah
JONES, EDGAR P.—*Zoology, Physiology*.....University of Akron, Akron
JONES, FRANCES L.—*Botany, Geology*.....1037 McMillan St., Cincinnati
JONES, GEORGE T.—*Botany*.....322 W. College St., Oberlin
JONES, LYNDS (F '20)—*Ornithology*.....352 W. College St., Oberlin
JONES, ORVILLE C.—*Geology*.....255 E. College St., Oberlin
JOSEPH, SISTER MARY, S.N.D.—*Biology*.....Notre Dame College, South Euclid

KARNES, LOWRY B.—*Geography*.....O. S. U., Columbus
KEHOE, ROBERT A. (F '33)—*Physiology*.....College of Medicine, Cincinnati
KELLEY, KENNETH L.—*Zoology*.....Kent State University, Kent
KELLY, HENRY A.—*Geology, Biology*.....316 W. Washington St., Howell, Mich.
KENDEIGH, S. CHARLES (F '35)*—*Biology*,
Experimental Zoology Laboratory, Champaign, Ill.
KENNEDY, CLARENCE H. (F '22)—*Entomology*.....O. S. U., Columbus
KERSTEN, HAROLD J. (F '39)—*Physics*.....University of Cincinnati, Cincinnati
KETTERING, CHARLES F.—*Physics*.....807 Winters Bank Bldg., Dayton
KING, DOROTHY D.—*Psychology*.....81 N. Warren Ave., Columbus
KITCHIN, PAUL C. (F '39)—*Medicine*.....O. S. U., Columbus
KLOEPFER, H. WARNER—*Zoology*.....134 W. Eighth Ave., Columbus
KNAUSS, HAROLD P.—*Physics*.....O. S. U., Columbus
KNOUFF, RALPH A. (F '32)—*Medical Sciences*.....O. S. U., Columbus
KNOX, GEORGE—*Physics, Applied Optics*.....83 Sixteenth Ave., Columbus
KNULL, JOSEF N. (F '36)—*Entomology*.....O. S. U., Columbus
KOCH, WENDELL R.—*Physics, Chemistry*, U. S. Army Corps, Wright Field, Dayton
KOSTIR, WENCEL J. (F '20)—*Zoology*.....O. S. U., Columbus
KRAATZ, WALTER C. (F '23)—*Zoology, Entomology*.....University of Akron, Akron
KRECKER, FREDERICK H. (F '20)—*Zoology*.....Ohio University, Athens
KRUEGER, LILLIAN K.—*Botany*.....1330 Eleanor Ave., Toledo
KUEHNLE, CHARLES H.—*Botany*.....2332 Tenth St., N. W., Canton

LACKEY, JAMES B.—*Protozoa, Ecology*.....Third and Kilgour Sts., Cincinnati
LAIRD, WILSON M.—*Geology*.....University of Cincinnati, Cincinnati

*Life member.

LAMB, G. F. (F '20)—*Geology*.....233 Hartshorn St., Alliance
LAMBERT, RAY—*Physics*.....3736 Woodburn Ave., Cincinnati
LAMBORN, MRS. HELEN MORNINGSTAR (F '20)—*Geology*,
224 Piedmont Road, Columbus
LAMBORN, R. E. (F '29)—*Geology*.....O. S. U., Columbus
LAMEY, CARL A. (F '39)—*Geology*.....2137 Waldeck Ave., Columbus
LAMPE, LOIS (F '31)—*Botany*.....O. S. U., Columbus
LAMPTON, ROBERT K.—*Botany*.....2621 Cheltenham Road, Toledo
LANDE, ALFRED—*Physics*.....O. S. U., Columbus
LANDIS, BIRELY J. (F '37)—*Entomology, Zoology*.....Box 30, Puyallup, Wash.
LANG, ALPHONSE—*Biology*.....Xavier University, Cincinnati
LANGLOIS, THOMAS H. (F '37)—*Ichthyology*.....Stone Laboratory, Put-in-Bay
LAPHAM, MARJORIE J.—*Zoology*.....40 E. South St., Painesville
LAWSON, CHESTER A.—*Zoology, Botany*.....Wittenberg College, Springfield
LEEDY, DANIEL L.—*Zoology, Ornithology*.....O. S. U., Columbus
LEWIS, ANNETTE L.—*Psychology*.....394 W. Seventh Ave., Columbus
LEWIS, CHARLES H.—*Chemistry*.....Harpster
LEWIS, ROBERT D.—*Botany*.....O. S. U., Columbus
LINDSEY, A. W. (F '27)—*Entomology, Zoology*.....Denison University, Granville
LINK, J. A.—*Medical Sciences*.....14 N. Limestone St., Springfield
LINSCHEID, ALFRED G.—*Biology*.....1901 Templehurst Drive, South Euclid
LOTZ, MRS. EDNA RICKEY—*Psychology*.....Kent State University, Kent
LYMAN, J. F.—*Chemistry*.....O. S. U., Columbus

MCAVOY, BLANCHE—*Biology*.....108 W. Ash St., Normal, Ill.
MCCAUGHEY, WM. J. (F '29)—*Geology, Chemistry*.....O. S. U., Columbus
MCCLURE, FLOYD A. (F '37)—*Botany*.....Lingnan University, Canton, China
MCCLURE, O. E.—*Physics, Chemistry*.....182 N. Congress St., Athens
MCCORMICK, ELIZABETH M.—*Conservation*.....667 Berkeley Road, Columbus
MCCORMICK, ROBERT N.—*Zoology*.....Ball State Teachers College, Muncie, Ind.
MCCULLOUGH, J. C.—*Chemistry, Psychology*.....153 S. Cedar St., Oberlin
MCEWEN, ROBERT S. (F '30)—*Zoology*.....Oberlin College, Oberlin
MCGREW, JOHN B.—*Physics, Chemistry*, 708 First National Bank Bldg., Springfield
MCNELLY, W. C. (F '38)—*Zoology*.....Miami University, Oxford
MCPHERSON, WILLIAM (F '20)—*Chemistry*.....198 Sixteenth Ave., Columbus
MACHLE, WILLARD—*Physiology*,
Kettering Laboratory, College of Medicine, Cincinnati
MAHARRY, JOHN P.—*Geography, Geology*.....413 W. Warren St., Youngstown
MANSON, EDMUND S., JR.—*Astronomy, Physics*.....O. S. U., Columbus
MANUEL, WILLIAM A.—(F '36)—*Chemistry*....Ohio Wesleyan University, Delaware
MARK, CLARA G. (F '20)—*Geology, Botany*.....270 S. State St., Westerville
MARTIN, CLARE (MR.)—*Chemistry, Physics*,
Bowling Green State University, Bowling Green
MARTIN, GEORGE C., JR.—*Geology*.....46 W. Tenth Ave., Columbus
MASON, HELEN M.—*Botany*.....R. F. D. 4, Newark
MASON, HORATIO C. (F '37)—*Entomology*.....151 W. Eleventh Ave., Columbus
MASTERS, CHARLES O.—*Biology*.....Western Reserve University, Cleveland
MATEER, FLORENCE (F '21)—*Psychology*.....37 N. Monroe Ave., Columbus
MATHENY, WILLIAM A. (F '22)—*Botany*.....Ohio University, Athens
MATHER, KIRTLEY F. (F '22)—*Geology*.....Harvard University, Cambridge, Mass.
MATHEWS, ALBERT P. (F '30)—*Biochemistry, Physiology*,
College of Medicine, Cincinnati
MATHEWS, C. O. (F '32)—*Psychology*.....57 N. Washington St., Delaware
MATHEWSON, STANLEY B.—*Psychology*.....Box 5, Melbourne Beach, Fla.
MAXFIELD, FRANCIS N. (F '32)—*Psychology*.....O. S. U., Columbus
MAYFIELD, SAMUEL M.—*Geology, Geography*,
Bowling Green State University, Bowling Green
MENDENHALL, EUGENE W.—*Entomology*.....97 Brighton Road, Columbus
METCALF, ZENO P. (F '32)—*Ornithology*....State College Station, Raleigh, N. Car.
METZLER, SIGMUND—*General Sciences*.....14 Cambridge Ave., Dayton
MEYER, BERNARD S. (F '30)—*Botany*.....O. S. U., Columbus
MILLER, DAVID F. (F '30)—*Zoology*.....O. S. U., Columbus

MILLER, DAYTON C. (F '20)—*Physics*...Case School of Applied Science, Cleveland
MILLER, EDITH MARIE—*Medical Pathology*.....Athens State Hospital, Athens
MILLER, MRS. ETHEL MELSHEIMER—*Botany, Zoology*.....O. S. U., Columbus
MILLER, EUGENE J.—*Geology*.....Loudonville Times, Loudonville
MILLER, FREDERICK N.—*Chemistry*.....Xavier University, Cincinnati
MILLER, FREEMAN D.—*Astronomy, Physics*.....308 N. Pearl St., Granville
MILLER, JOHN A. (F '36)—*Zoology*.....O. S. U., Columbus
MILLER, JOSEPH N.—*Zoology*.....O. S. U., Columbus
MILLER, VERNON L.—*Psychology*.....47 Harpswell St., Brunswick, Maine
MILLER, WARREN C.—*Entomology*.....111 Ellenwood Ave., Bedford
MITCHELL, ROBERT H.—*Geology, Chemistry*.....Muskingum College, New Concord
MOGENDORFF, NICHOLAS (F '36)—*Botany*.....University of Toledo, Toledo
MOKE, CHARLES B.—*Geology*.....College of Wooster, Wooster
MOLZ, FRANCIS J.—*Biology*.....University of Dayton, Dayton
MOON, M'DELLA—*Botany*.....Bluffton College, Bluffton
MOORE, DWIGHT M.—*Botany*.....University of Arkansas, Fayetteville, Ark.
MORGAN, GEORGE D.—*Zoology*.....Denison University, Granville
MORREY, C. B. (F '20)—*Bacteriology*.....317 N. Dixie Road, South Miami, Fla.
MORSE, WM. C. (F '20)—*Biology*.....University of Mississippi, University, Miss.
MOSELEY, EDWIN L. (F '20)—*Zoology, Botany*.....Bowling Green
MOSES, C. F.—*Geology*.....1164 E. Main St., New Concord
MOULTHROP, PHILIP N.—*Ornithology*.....2717 Euclid Ave., Cleveland
MOYER, HARVEY V. (F '35)—*Chemistry*.....O. S. U., Columbus
MUEGEL, HARRY R.—*Botany*.....University of Cincinnati, Cincinnati
MUNN, LOTTIE E.—*Chemistry*.....Lake Erie College, Painesville
MYERS, GARRY C. (F '27)—*Psychology*.....2525 Euclid Ave., Cleveland Heights
MYERS, R. MAURICE—*Botany*.....Northwestern University, Evanston, Ill.

NEISWANDER, CLAUDE R. (F '32)—*Zoology*,
Ohio Agricultural Experiment Station, Wooster
NEISWANDER, RALPH B.—*Entomology, Botany*,
Ohio Agricultural Experiment Station, Wooster
NELSON, JAMES A. (F '20)—*Zoology*.....Gambier
NELSON, R. H.—*Entomology*.....182 E. Pacemont Road, Columbus
NOLAN, ALFRED F.—*Medicine*,
Kentucky Agricultural Experiment Station, Lexington, Ky.
NORRIS, FRED H.—*Botany*.....O. S. U., Columbus
NOVY, WM. S.—*Zoology*.....1853 E. 89th St., Cleveland
NUSBAUM, CHRISTIAN—*Physics*.....Case School of Applied Science, Cleveland

OBERHOLSER, H. C. (F '21)—*Zoology*.....2805 18th St. N. W., Washington, D. C.
OHIO STATE UNIVERSITY LIBRARY.....O. S. U., Columbus
O'NEAL, CLAUDE E. (F '20)—*Botany*.....Ohio Wesleyan University, Delaware
ORR, GROVER L.—*Chemistry*.....767 College Ave., Columbus
OSBORN, HERBERT (F '20)—*Zoology, Entomology*.....O. S. U., Columbus
OSBURN, RAYMOND C. (F '20)—*Zoology*.....O. S. U., Columbus
OSGOOD, THOMAS H.—*Physics*.....University of Toledo, Toledo
OTIS, CHARLES H. (F '20)—*Botany*,
Bowling Green State University, Bowling Green
OWENS, WM. E.—*Zoology*.....779 Oxford St., Worthington

PALINCHAK, STEVE—*Chemistry, Physics*.....2546 Auburn Ave., Cincinnati
PALMER, DWIGHT M.—*Medical Sciences*.....O. S. U., Columbus
PAPPENHAGEN, LOUIS A. (F '37)—*Chemistry*.....705 W. State St., Alliance
PARK, J. B. (F '30)—*Agronomy*.....O. S. U., Columbus
PARK, ORLANDO—*Zoology*.....Northwestern University, Evanston, Ill.
PARKS, T. H. (F '20)—*Entomology*.....O. S. U., Columbus
PASCHALL, ALFRED H.—*Geology*.....333 W. Norman Ave., Dayton
PATRICK, JAMES R. (F '32)—*Psychology*.....98 University Terrace, Athens
PEATTIE, RODERICK (F '33)—*Geography*.....O. S. U., Columbus
PERSING, ELLIS C.—*Biology*.....3316 Warrington Road, Shaker Heights

PESKIND, A.—*Medical Sciences*.....2409 E. 55th St., Cleveland
PETERSON, ALVAH (F '30)—*Entomology*.....O. S. U., Columbus
PETERSON, VINCENT R.—*Botany*.....1952 Nellawood Road, Cleveland
PONTIUS, LESLIE L.—*Botany, Zoology*.....170 W. High St., Circleville
POOL, M. L.—*Physics*.....O. S. U., Columbus
POOS, FREDERICK W.—*Entomology*.....Arlington Experiment Farm, Rosslyn, Va.
POPHAM, RICHARD A.—*Botany*.....O. S. U., Columbus
PORTER, HAROLD L.—*Botany*.....Marengo
PORTER, JAMES P. (F '30)—*Psychology*.....Ohio University, Athens
PORTER, T. WAYNE—*Zoology, Ornithology*.....327 W. Water St., Oak Harbor
PORTER, WALTER P.—*Botany, Zoology*.....135 Grosvenor St., Athens
POWELL, G. W. H.—*Chemistry*.....Urbana Junior College, Urbana
PRATHER, W. D.—*Chemistry, Biology*.....408 Broadway, Aurora, Ind.
PRESSEY, SIDNEY L. (F '32)—*Psychology*.....O. S. U., Columbus
PRICE, JOHN W. (F '32)—*Zoology*.....O. S. U., Columbus
PUTERBAUGH, M. P.—*Chemistry*.....Ashland College, Ashland
PYLE, W. R.—*Physics*.....240 Fife Ave., Wilmington

QUILL, LAURENCE L. (F '39)—*Chemistry*.....O. S. U., Columbus
QUIRING, DANIEL P.—*Biology*.....Western Reserve University, Cleveland

RANKIN, JOHN P.—*Biology, Medicine*.....Elyria Savings and Trust Bldg., Elyria
RAY, FRANCIS E. (F '39)—*Chemistry*.....University of Cincinnati, Cincinnati
RENSHAW, SAMUEL (F '30)—*Psychology*.....O. S. U., Columbus
REYNOLDS, RALPH J.—*Botany, Zoology*.....2645 Powell Ave., Columbus
RICE, EDWARD L. (F '20)—*Zoology*.....265 N. Sandusky St., Delaware
RICH, JOHN L. (F '39)—*Geology*.....University of Cincinnati, Cincinnati
RICHARDS, C. F.—*Psychology*.....Denison University, Granville
RICHARDS, WILFRED G.—*Geography*.....337 Maple St., Oxford
RIEVESCHL, GEORGE, JR.—*Chemistry, Physics*.....112 Mill St., Lockland
RIFE, D. C.—*Zoology, Botany*.....O. S. U., Columbus
RING, DEWITT T.—*Geology, Geography*.....805 Atlas Bldg., Columbus
RING, GORDON C.—*Physiology*.....O. S. U., Columbus
ROACH, LEE S.—*Zoology*.....Ohio University, Athens
ROBINSON, J. M.—*Entomology*.....Alabama Polytechnic Institute, Auburn, Ala.
ROCKWOOD, RUTH C.—*Geography*.....119 Greenwood Heights, Bellevue
ROGERS, A. SOPHIE (F '27)—*Psychology*.....O. S. U., Columbus
ROGERS, CHARLES G. (F '20)—*Physiology*.....378 Reamer Place, Oberlin
ROGICK, MARY D.—*Zoology*.....College of New Rochelle, New Rochelle, N. Y.
ROOD, ALMON N.—*Botany*.....Phalanx Station
ROSZMAN, FOSTER D.—*Ecology, Ichthyology*,
Bowling Green State University, Bowling Green
ROTHEMUND, PAUL (F '36)—*Chemistry*.....Antioch College, Yellow Springs
ROTHERMEL, JULIA E.—*Zoology*.....Western College, Oxford
ROUSE, JOHN T.—*Geology*.....Box 780, Tyler, Texas
ROWLES, EMMETT—*Zoology*.....97 Franklin Ave., Athens
RUNNELS, HARMON A.—*Botany*....Ohio Agricultural Experiment Station, Wooster

SALETEL, LOUIS—*Geology*.....University of Dayton, Dayton
SALISBURY, R. K.—*Botany*.....Greenhills, Cincinnati
SAMPSON, HOMER C. (F '20)—*Botany*.....O. S. U., Columbus
SAWYER, CARL W.—*Medical Sciences*.....White Oaks Farm, Marion
SAYRE, JASPER D. (F'22)—*Botany*, Ohio Agricultural Experiment Station, Wooster
SCHAEFER, PAUL E.—*Zoology, Entomology*.....O. S. U., Columbus
SCHALLER, RALPH A.—*Botany*.....124 S. College Drive, Bowling Green
SCHEAR, E. W. E. (F '37)—*Biology*.....Otterbein College, Westerville
SCHMIDT, JACOB J.—*Geology*.....East Ohio Gas Company, Cleveland
SCHOTT, RALPH G. (F '37)—*Genetics*.....Box 64, Beltsville, Md.
SCHWARZBEK, WILLIAM—*Psychology*.....Wittenberg College, Springfield
SCOFIELD, EDWARD H.—*Psychology*.....1811 Harvard Drive, Louisville, Ky.
SCUDDER, E. D.—*Chemistry*.....Youngstown College, Youngstown

SEAMAN, ELWOOD A.—*Botany, Biology*.....1369 Beall Ave., Wooster
SEARS, PAUL B. (F '39)—*Botany*.....Oberlin College, Oberlin
SECREST, EDMUND (F '24)—*Forestry*,
Ohio Agricultural Experiment Station, Wooster
SEMANS, FRANK M.—*Zoology*.....North Jackson
SETON, SISTER ELIZABETH—*Biology*....College of Mt. St. Joseph, Mount St. Joseph
SEYMOUR, RAYMOND J. (F '20)—*Physiology*.....O. S. U., Columbus
SHADLE, ALBERT R.—*Zoology*.....University of Buffalo, Buffalo, N. Y.
SHANKLAND, ROBERT S.—*Physics*.....Case School of Applied Science, Cleveland
SHANKS, ROYAL E.—*Botany*.....University of Tennessee, Knoxville, Tenn.
SHARP, WINFORD L.—*Psychology*.....College of Wooster, Wooster
SHARPE, C. F.—*Geology, Geography*.....1062 W. High Ave., New Philadelphia
SHATZER, CHARLES G. (F '20)—*Geology, Geography*, Wittenberg College, Springfield
SHELLHAAS, MARK A.—*Zoology*.....241 N. Main St., West Milton
SHETRONE, HENRY C. (F '31)—*Archaeology*.....O. S. U., Columbus
SHIDELER, W. H. (F '20)—*Geology*.....Miami University, Oxford
SHILLING, E. R., JR.—*Botany*.....Kent State University, Kent
SIEKERES, ALBERT—*Zoology, Physics*.....Kipton
SINNETT, RALPH V.—*Chemistry*.....95 Oak Hill Ave., Delaware
SITES, JOHN M.—*Horticulture, Botany*.....1907 Auburn Ave., Dayton
SMITH, ALPHEUS W. (F '22)—*Physics*.....O. S. U., Columbus
SMITH, ERNEST R. (F '21)—*Geology*.....DePauw University, Greencastle, Ind.
SMITH, GUY-HAROLD (F '32)—*Geography*.....O. S. U., Columbus
SMITH, LEON E. (F '39)—*Physics*.....Denison University, Granville
SMITH, RUTH ELIZABETH—*Geology*.....109 Lakeside, New Concord
SNODDY, A. O.—*Chemistry*.....R. F. D. 6, Cincinnati
SNYDER, LAURENCE H. (F '32)—*Zoology*.....O. S. U., Columbus
SOLBERG, A. N.—*Genetics, Physiology*.....University of Toledo, Toledo
SOUTHWICK, ERMAN D.—*Geology*.....334 Second St., Marietta
SPANDAU, H. M.—*Botany*.....31 Park Blvd., Mansfield
SPENCER, WARREN P. (F '29)—*Zoology*.....702 N. Bever St., Wooster
SPERTI, GEORGE S.—*Scientific Research and Education*,
6616 Beechmont Ave., Cincinnati
STAUFFER, CLINTON R. (F '20)*—*Geology*,
University of Minnesota, Minneapolis, Minn.
STEHR, WILLIAM C. (F '33)—*Zoology, Entomology*.....Ohio University, Athens
STEIDTMANN, WALDO E.—*Botany*,.Bowling Green State University, Bowling Green
STEPHENSON, LEONARD L.—*Botany*.....Buchtel
STEWART, GRACE A. (F '27)—*Geology*.....O. S. U., Columbus
STICKNEY, M. E. (F '20)—*Botany*.....Denison University, Granville
STOCKDALE, PARIS B. (F '24)—*Geology*.....O. S. U., Columbus
STOLTZ, ROBERT B.—*Dairy Technology*.....O. S. U., Columbus
STONE, JULIUS F.—*General Science*.....Seagrave Company, Columbus
STOUT, HARRY O.—*Botany, Geology*.....402 Buttonwood Ave., Bowling Green
STOUT, WILBER (F '20)—*Geology*.....O. S. U., Columbus
STOVER, ERNEST L. (F '30)—*Botany*,
Eastern Illinois State Teachers College, Charleston, Ill.
STOVER, WILMER G. (F '20)—*Botany*.....O. S. U., Columbus
STRETE, RALPH F.—*Geology*.....Rockford
STRICKLER, MRS. NELLIE F. HENDERSON (F '26)—*Botany*.....R. R. 1, Hilliards
STUMM, ERWIN O.—*Geology*.....Oberlin
STURGEON, MYRON T.—*Geology*, Michigan State Normal College, Ypsilanti, Mich.
SUDLOW, PAUL L.—*Botany*.....Rio Grande College, Rio Grande
SUMNER, CHARLES B.—*Biology*.....Kent State University, Kent
SURRARRER, THOMAS C.—*Zoology*.....Baldwin-Wallace College, Berea
SUTTON, T. SCOTT—*Organic and Bio-chemistry*.....O. S. U., Columbus

TAFT, CLARENCE E.—*Botany*.....O. S. U., Columbus
TASHIRO, SHIRO (F '29)—*Medical Sciences*.....College of Medicine, Cincinnati
TAYLOR, ARAVILLA M.—*Biological Sciences*.....Lake Erie College, Painesville

*Life member.

TAYLOR, MRS. BAYARD—*Botany*.....West Jefferson
TAYLOR, L. W. (F '29)—*Physical Sciences*.....Oberlin College, Oberlin
TEDESCHE, LEON G.—*Medical Sciences*.....1016 Valley Lane, Avondale, Cincinnati
THOMAS, EDWARD S. (F '37)—*Ornithology*.....O. S. U., Columbus
THOMAS, ROY C. (F '23)—*Botany, Zoology*,
Ohio Agricultural Experiment Station, Wooster
THOMPSON, ISABEL, *Botany, Ecology*,
14 Milton Apts., High St. and Ninth Ave., Columbus
THOMPSON, OSCAR E.—*Zoology*.....111 E. Fourteenth St., Holland, Mich.
THORNTON, C. S.—*Biology*.....Kenyon College, Gambier
THUT, HIRAM F. (F '34)—*Botany*,
Eastern Illinois State Teachers College, Charleston, Ill.
TIDD, WILBUR M.—*Zoology*.....O. S. U., Columbus
TIFFANY, LEWIS H. (F '23)—*Botany*.....Northwestern University, Evanston, Ill.
TILFORD, PAUL E.—*Botany*.....Ohio Agricultural Experiment Station, Wooster
TOOMEY, JOHN A. (F '39)—*Medical Sciences*.....City Hospital, Cleveland
TOOPS, HERBERT A. (F '24)—*Psychology*.....O. S. U., Columbus
TOOPS, MRS. HERBERT A.—*Psychology*.....458 W. Eighth Ave., Columbus
TRANSEAU, EDGAR N. (F '20)—*Botany*.....O. S. U., Columbus
TRAUTMAN, MILTON B.—*Ornithology*.....Stone Laboratory, Put-in-Bay
TRIMBLE, CHARLES A.—*Entomology*.....O. S. and S. O. Home, Xenia
TUCKER, WALTER A.—*Zoology, Botany*.....728 S. Remington Road, Columbus
TURNER, CLARENCE L. (F '20)—*Zoology*..Northwestern University, Evanston, Ill.

ULLMAN, ROY R.—*Psychology*.....227 Ferrell Ave., Ashland
URBAN, SISTER MARY O P.—*Botany, Zoology*...St Mary of the Springs, Columbus

VALENTINE, WILLARD (F '32)—*Psychology*.....O. S. U., Columbus
VAN CLEEF, EUGENE (F '32)—*Geography*.....O. S. U., Columbus
VAN HORN, JESSE L.—*Chemistry, Physics*.....1490 Roycroft Ave., Lakewood
VAN WORMER LIBRARY.....University of Cincinnati, Cincinnati
VAUGHN, JAMES—*Psychology*.....413 McAlpin, Cincinnati
VENARD, CARL—*Zoology*.....O. S. U., Columbus
VERMILLION, MONROE T.—*Botany*.....Ohio University, Athens
VER STEEG, CARL (F '31)—*Geology, Geography*.....1105 Quinby Ave., Wooster
VISSCHER, J. PAUL (F '29)—*Biology, Medical Sciences*,
Western Reserve University, Cleveland
VIVIAN, ALFRED (F '20)—*Agriculture, Chemistry*....185 Piedmont Road, Columbus
VOLK, LLOYD E.—*Zoology*.....Ohio Wesleyan University, Delaware
VON DACH, HERMAN—*Zoology*.....O. S. U., Columbus
VON SCHLICHTEN, OTTO C. (F '29)—*Geology*....University of Cincinnati, Cincinnati

WAITE, FREDERICK C. (F '20)—*Anatomy, Zoology*..2109 Adelbert Road, Cleveland
WALKER, CHARLES F.—*Ornithology*.....Stone Laboratory, Put-in-Bay
WALLACE, ATWELL M.—*Botany, Chemistry, Geology*,
U. S. D. A. Soil Conservation Service, 2223 Fulton St., Berkeley, Calif.
WALLACE, CLARENCE W.—*Physics*.....Case School of Applied Science, Cleveland
WALLACE, S. R.—*Psychology*.....Tulane University, New Orleans, La.
WALLER, ADOLPH E. (F '20)—*Botany*.....O. S. U., Columbus
WAREHAM, RICHARD T.—*Botany*.....O. S. U., Columbus
WARNER, EDWARD N.—*Zoology*.....O. S. U., Columbus
WATT, LUCY J.—*Zoology*.....Western College, Oxford
WEED, R. B.—*Geology*.....244 W. Gay St., Columbus
WEISHAUPT, CLARA G.—*Botany*.....State Teachers College, Jacksonville, Ala.
WENE, GEORGE P.—*Zoology*.....O. S. U., Columbus
WESTGATE, L. G. (F '20)—*Geology*.....124 Oak Hill Ave., Delaware
WHITE, C. LANGDON—*Geography*.....Western Reserve University, Cleveland
WHITE, GEORGE W. (F '32)—*Geology*,
University of New Hampshire, Durham, N. H.
WICKLIFF, EDWARD L. (F '23)—*Zoology*.....O. S. U., Columbus
WIEBE, A. H.—*Biology*.....Tennessee Valley Authority, Norris, Tenn.

WILLARD, C. J. (F '24)—*Agronomy, Botany*.....O. S. U., Columbus
WILLIAMS, ARTHUR B.—*Ecology*.....2717 Euclid Ave., Cleveland
WILLIAMS, R. D.—*Psychology*.....O. S. U., Columbus
WILLIAMS, STEPHEN R. (F '20)—*Biology*.....Miami University, Oxford
WILLIAMSON, C. O.—*Mathematics*.....College of Wooster, Wooster
WILSON, IRA T. (F '35)—*Zoology*.....Heidelberg University, Tiffin
WILSON, MRS. J. WATSON—*Botany*.....Muskingum College, New Concord
WING, DAVID G.—*Biology, Chemistry*.....Mechanicsburg
WINTER, A. R.—*Zoology*.....O. S. U., Columbus
WISEMAN, B. K. (F '37)—*Medical Sciences*.....O. S. U., Columbus
WITHROW, JAMES R. (F '20)—*Chemistry*.....O. S. U., Columbus
WOLFE, JOHN N.—*Botany*.....O. S. U., Columbus
WOLFORD, JOHN J. (F '38)—*Geology*.....Miami University, Oxford
WRIGHT, ALFRED J.—*Geography*.....O. S. U., Columbus
WRIGHT, FRANK J. (F '29)—*Geology*.....Box 382, Granville
WURDACK, MARY E.—*Botany*.....68 Chatham Road, Columbus

YATES, PAUL B.—*Medicine*.....O. S. U., Columbus
YOCUM, LINCOLN A.—*Medicine*.....Wooster
YOUNG, H. C. (F '26)—*Botany*....Ohio Agricultural Experiment Station, Wooster
YOWELL, EVERETT I.—*Astronomy, Mathematics*.....3127 Griest Ave., Cincinnati
YUNCK, GEORGE F.—*Geology*.....Pure Oil Company, Clay City, Ill.

ZIMPFER, PAUL—*Botany*.....Capital University, Columbus
ZWICK, KARL G.—*Medical Sciences*.....19 Garfield Place, Cincinnati